Does Monetary Policy Have an Effect on Stock Prices? Evidence from the United Kingdom and Finland Between the Years 2003-2018 Using the Structural Vector Autoregression Model.

Anmol Kaur

University of Helsinki

Faculty of Social Sciences

Economics

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This thesis aims to answer the question of whether monetary policy influences stock prices in the United Kingdom and Finland. These countries have been chosen due to their economic differences. The United Kingdom is an open relatively large economy with an independent monetary policy set by the Bank of England. Finland, on the other hand is a small open economy, and it is part of a monetary union called Eurozone. Hence, the monetary decisions are made by the European Central Bank for all the members of the union. The research is conducted for the time period of 15 years (2003-2018) with monthly time-series data. The method used in the thesis is the structural vector autoregression model which allows for solving the endogeneity issue through imposing restrictions on the structure of the model. Hence, short-run restrictions and long-run monetary neutrality are applied to the model.

The model is analysed using the estimation as well as impulse response functions. In order to consider the macroeconomic environment, variables such as inflation, commodity prices, and industrial production are used in the model. Moreover, a dummy variable is used to account for the financial crisis of 2007-2009. The results of the structural vector autoregression estimation show there to be a statistically significant negative effect of monetary policy on stock prices for both countries. The impulse responses show that as contractionary monetary policy is implemented, stock prices tend to decrease. Contrarily, expansionary monetary policy results in an increase of stock prices. The effect of a monetary policy shock is larger on the stock prices and dissipates quicker in the United Kingdom. For Finland, the effect is minor, and it takes longer to dissipate. However, the effect is statistically significant for both countries.

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1. Introduction

The financial crisis of 2007-2009 was the most significant crisis after the Great Depression of 1929. The more recent crisis has started a debate about the relationship between monetary policy and asset prices. Many Eurozone countries were in trouble because of the crisis, which led the European Central Bank (ECB) to significantly increase the availability of money. Around the same time, many major banks in the United Kingdom (UK), most notably Lloyds Bank, were seeing troubles as well. The Bank of England then opted for decreasing the interest rates and adapting the quantitative easing (QE) by increasing the money supply through the purchase of the UK gilts. The expansionary monetary policy and low (sometimes negative) real short-run interest rates after the crisis have increased the availability of money. Hau and Lai (2016) believe that leverage expansion has increased the opportunity costs for low-risk investments. It has been evident that stock markets particularly are sensitive to monetary policy changes (Li, İşcan, and Xu, 2010). Contrarily, movements in stock prices may have a significant effect on macroeconomy, which would affect the monetary policy decisions. Monetary policy in the Eurozone is regulated by the European Central Bank (ECB), and its decisions are rarely based on a single economy. Hence, there is not an endogeneity issue as one country's macroeconomic conditions do not affect the monetary policy.

This thesis aims to study the impact of monetary policy on stock prices. The chosen time-period for the analysis is 2003-2018, and the countries of discussion are Finland and the UK. Finland is chosen as it represents a relatively small open economy, which is very much dependent on trade. Moreover, Finland is part of the Eurozone, and the monetary policy is decided by the European Central Bank, which then affects the domestic interest rates. The UK, in contrast, is a large open economy and has its own monetary policy as it is not part of the monetary union (Eurozone). To account for the endogeneity issues and the effects of other macroeconomic variables, inflation, commodity prices and industrial production are included in the model. Moreover, a dummy for financial crisis in 2007-2009 is used.

The structure of the thesis is as follows. Section 1 comprises the introduction with essential information about the thesis. In addition, this section discusses the background information on the topic with aims and objectives. Followed by section 1, section 2 is the literature review. For the literature review, previous literature, and the theories surrounding the topic of asset pricing and monetary policy are presented. Section 3 is methodology, where the methods used in this thesis, data sources with a detailed description of the chosen model, and some methods are discussed. Section 4 is dedicated to the obtained results. The results are analysed by linking the findings to theories and previous literature. Lastly in section 5, a conclusion with policy implications and future possibilities for the topic are discussed.

1.1 Aims and Objectives

This research aims to study how monetary policy affects stock prices in two very different economies. One is a small open economy with no independent monetary policy as it is a part of a larger union (Finland), whereas the other one is a large open economy with independent monetary policy (the UK). Hence, it is interesting to see how two completely different economies react to monetary policy changes, and whether monetary policy is a significant factor for the changes in asset prices.

1.2 Research Contribution and Expected Results

This thesis contributes to the available literature by using the structural vector autoregression (SVAR) method and combining the monetary policy with other macroeconomic variables to study their effects on stock prices for a unique time-period that has not been used before. The research focuses on two very different economies—the UK and Finland, and the combination of these two economies for such topic has not been studied. In fact, there are no published papers regarding the topic in Finland for the chosen time period. The results expected from this research are that monetary policy has a statistically significant effect on stock prices in both countries. The effect is also expected to be negative following the previous literature.

2. Literature Review

This section discusses the literature that is already available about the topic of this thesis. The literature review discusses theoretical as well as empirical literature. The theoretical literature review is presented as it acts as a base for the empirical framework. Moreover, the theoretical literature review brings together the economic theories surrounding the topics. These theories are often used as a justification for the policy changes as well as to explain the financial market movements. The structure of this section is as follows. Firstly, the theoretical literature review is discussed with a detailed description of the theories concerning monetary policy and asset returns. The theoretical literature review is then followed by the empirical literature review, which addresses the methods and variables that other authors have used to study this topic. Most importantly, the empirical section focuses on the methodology of the papers. Lastly, a brief conclusion of the literature review section is provided.

2. 1 Theoretical Literature Review

Theoretical models concerning asset pricing aim to explain the determinants of financial returns with the help of risk measures and volatility calculations. Although the focus of this thesis is the relationship between monetary policy and stock returns, it is essential to address the theories explaining the stock returns. The most well-known model is the Capital Asset Pricing Model (CAPM), which uses different market components that derive the movements in stock returns. The following sections explain the Capital Asset Pricing Model, followed by a brief description of the Arbitrage Pricing Theory and the Efficient Market Hypothesis. Moreover, the later sections define the Taylor Rule as it provides a theoretical base for the monetary policy. Lastly, the monetary policy differences of the chosen countries and the relationship between asset prices and monetary policy are discussed.

2.1.1 Capital Asset Pricing Model

The most significant theory explaining the asset returns is the Capital Asset Pricing Model (CAPM). The theory explains how the returns of different assets (securities, stocks bonds, derivatives, and others) are determined in financial markets (Singla, 2008). The CAPM is based on a two-parameter portfolio analysis model that was first introduced by Markowitz (1952). According to the model, the risk-free rate and the risk premium determine the expected returns of assets. Hence, market risk is the single factor that affects asset returns, and it is the undiversifiable risk that determines the returns. Undiversifiable risk is the risk that cannot be eliminated by portfolio diversification. According to Smart, Gitman and Joehnk (2017), such risk is a result of market forces that cannot be assigned to a specific investment because they affect all of the investments. For example, interest rates, inflation, real output, and political events are such forces. Thus, investors want compensation for the undiversifiable risk in the form of the risk premium.

The model relies on the following assumptions:

- At the risk-free rate, the investors can borrow and lend without any restrictions
- All the assets are available in the market
- The capital markets are perfect
- There is transparency in the market, and information is costless and available to everyone
- The expectations of investors are homogenous, meaning that all the investors have the same expectations
- All investors are risk-averse
- When making decisions, investors are only interested in the mean and standard deviation of terminal wealth
- There are no limits to the division of assets
- No taxes or transactions costs exist

Some of the assumptions regarding the CAPM may seem unrealistic. However, according to Singla (2008), they can be relaxed, and the model would still yield accurate results. The CAPM equation is presented as follows:

$$E_{Ri} = R_f + [\beta_i(E(R_m) - R_f)] \quad (1)$$

where the expected return of investment is ERi, the risk-free rate is Rf, the beta that accounts for the undiversifiable risk is denoted by βi, and the expected market return which is the average return on all securities is denoted by $E(Rm)$. The risk premium is denoted by $[\beta i$ $(E(Rm) - Rf)]$. Graphically, the security market line (SML) is used to demonstrate the model (Smart et al., 2017). The SML represents the relationship between the market return and the expected return. Figure 2.1 presents the graphical model with the required return (%) on the y-axis and the risk (beta) on the x-axis. The figure shows how the required return increases as the investment risk increases. For the additional risk, investors as for the risk premium, which is the area between the SML and risk-free rate.

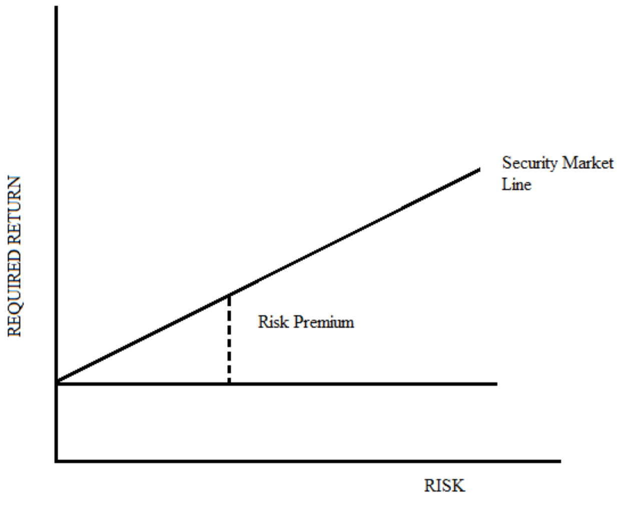

Figure 2. 1: Security market line. Source: (Smart et al., 2017, p. 219)

2.1.2 The Arbitrage Pricing Theory

The arbitrage pricing theory (APT), which derives from the CAPM, states that the risks of standard macroeconomic variables can explain the variations in the asset returns. To explain the returns of an asset, the model utilizes multiple risk factors. As per the APT, in the case of a well-diversified portfolio, there is no possibility of arbitrage. If there was an option of arbitrage, other investors would exploit it. The theory applies to both aggregate stock markets and individual stocks. Hence, the APT is a useful theory for explaining the effects of macroeconomic variables on stock prices. Moreover, the theory states that the relationship between expected returns and covariance of the assets and factors is linear.

The APT has become popular as the CAPM is criticized because it does not explain the asset returns empirically. According to Huberman (2005), both the theories are similar as they both state there to be a linear relationship between random variables and the asset returns (and their covariances). However, the most significant difference is that the ATP does not rely on utility assumptions. In addition, the APT can explain cases that are about a single-or multiperiod as it is not a single-period model. The APT is more flexible than the CAPM as it does not require the market portfolios to be efficient.

2.1.3 The Efficient Market Hypothesis

According to the Efficient Market Hypothesis (EMH), financial market information is exceptionally efficient. The asset returns, thus, reflect the market entirely. The EMH states that the news in financial markets spread so rapidly that they affect the pricing of the assets immediately (Malkiel, 2003). Therefore, the fundamental and technical analyses are incompetent. Fundamental analysis refers to predicting future stock prices by using past prices, whereas technical analysis focuses on financial information to determine the undervalued stocks. However, these techniques cannot be applied according to the EMH as the returns would not be any better than the returns of a random portfolio. There are three forms to the EMH – weak form efficiency, semi-strong efficiency, and strong efficiency.

The weak form efficiency is closely related to the random walk hypothesis. According to the weak form, stock prices are unaffected by their past values, thus following a 'random walk.' The hypothesis states that stock prices reflect the latest market information. Hence, the past values do not matter; only the most recent information does. The unpredictability of news also makes stock prices unpredictable. The semi-strong form of the EMH states that stock prices reflect all the publicly available information. Again, consistently obtaining abnormal profits is not possible because stock prices adjust to the information (Malkiel, 2003). The last form, which is the strong form, states that in addition to the public information, the stock prices reflect all the private information as well. Although employees are usually prohibited from trading the stocks of the company they work for before the official announcements are made, some employees may not follow this rule. Moreover, the information may leak illegally, which would then be reflected in the stock prices.

2.1.4 Stock Market and The Business Cycle

The importance of the stock market in economics may not be straightforward. To justify the importance of stock prices in the business cycle, Naes, Skjeltorp, and Ødegaard (2011) show that there is a strong relationship between stock market liquidity and the business cycle. The business cycle indicates the movements in the production output of goods and services. The cycles are often measured by using the real[1] gross domestic product (GDP). As per Naes et al. (2011), the stock market liquidity can be considered as a leading indicator of what is occurring in the real economy. This is demonstrated in Figure 2.2, which consists of grey bars that represent recession periods and the detrended illiquidity ratio (ILR) plots. The figure is obtained by using time-series plots over the time-period 1947-2008 for the United States. Movements in prices caused by the trading volume are indicated by the ILR, which is considered to be an elasticity measure of the price impact. High value of the ILR is an indication that trades have a high price impact. The figure shows that there is an apparent relationship between the recessions and high stock market illiquidity. As illiquidity in the stock market increases, recessions are likely to occur as a consequence or as an indicator of investor confidence. Moreover, stock prices are often the expected discounted value of future prospects, therefore, they are indicator of future economic growth. These prices change as the expected

[1] Real = Adjusted for inflation

future dividend growth or the expected income changes (Millard and Power, 2004). The asset prices may also change when the discount factor changes which contains the risk-free interest rate and risk premium.

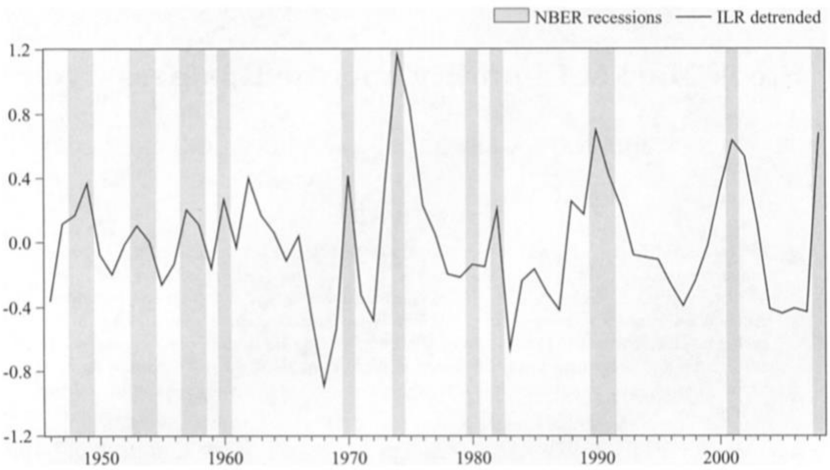

Figure 2. 2: Liquidity and the business cycle by Naes, Skjeltorp and Ødegaard, The Journal of Finance, 2011.

As per Pedersen and Brunnermeier (2005) there is a relationship between the liquidity of the securities market and the availability of funds by financial intermediaries. According to their model, liquidity provider’s capital and margin requirements determine whether there is a possibility to provide liquidity. Hence, financial crises lead to liquidity spirals as funding liquidity decreases and liquidity providers prefer to provide liquidity to stocks with low margins. During the financial crisis of 2008, funding liquidity and high undiversifiable risk distributed to the real economy from the financial market. Stock market liquidity may also affect the real economy through investment channels. A liquid stock market may encourage investors to invest into illiquid high productivity projects that are long-term. This in turn leads to problems when these projects underperform.

2.1.5 Monetary Policy and the Taylor Rule

Monetary policy is the tool that central banks use to control the money supply. The most significant channel of the policy is the interest rate. The central bank can set the interest rate and increase/decrease the cost of spending. If the bank implements expansionary monetary policy, they decrease the interest rates, making borrowing cheaper. Contrarily, the contractionary monetary policy works to decrease the money supply by increasing the interest rates and increasing the cost of borrowing (Bank of England, 2019). Another channel that the monetary policy works through is QE. When implementing the QE, the central bank buys government securities or other securities, which increases the money supply through increasing investment and lending (The Economist, 2019). The QE is the digital way of creating money – creating digital cash through buying securities. The quantity of assets purchased determines how much the bank reserves increase because of the QE. Hence, the purpose is that the banks would use this money to replace the assets they have sold to the central bank by buying new assets. Because banks increase the purchase of assets, the stock prices rise, and interest rates decrease, increasing the investment opportunities. Hence, quantitative easing is part of expansionary monetary policy. The target of such policy is to stimulate the economy as banks are encouraged to create loans.

To determine how to use interest rates to account for inflation and other economic activity, John Taylor proposed a principle known as the Taylor Rule. When the inflation is more than the target inflation rate set by the central bank, according to the Taylor Rule, the interest rates should be increased. The same policy is suggested if the output growth is above its potential or too high. Contrarily, the interest rates should be decreased when the output growth is slow and inflation is below its target (Woodford, 2001). The formula of the regarding the rule is the following:

$$i_t = \pi_t + r_t^* + 0.5(\pi_t - \pi^*) + 0.5(y_t - \bar{y}_t) \tag{2}$$

where i_t denotes the operating target rate, π_t is the inflation rate, $r_t{}^*$ represents the real interest rate, π^* denotes the inflation target rate, y_t is the real Gross Domestic Product (GDP) in logarithmic form, and $\bar{y}_t$ denotes the potential output in its logarithmic form. Hence, according to the rule, the optimal interest rate target is a product of the key macroeconomic variables. The equation is a simple way to determine the consequences of policy decisions. This is significant for the analysis of monetary policy effects as monetary policy is targeted to ensure price stability as well as combat recessions. The Taylor rule takes both business cycle and inflation into account with the variables included in the equation.

2.1.6 Monetary Policy in Finland and the UK

There are fundamental differences between Finland and the UK regarding the monetary policy. Finland is part of the Eurozone, which means that it is part of a union where a singular monetary policy is implemented for all the members by the European Central Bank (ECB). Because of this, changes in one country's macroeconomic conditions (inflation, GDP etc.) do not affect the policy decisions made by the ECB. Having such a monetary union eliminates any exchange rate risks between the members as well as lowers costs related to cross-border transactions (Japelli and Pistaferri, 2011). This allows for a financial market that is entirely integrated.

The UK has its own currency (Sterling Pound) and its own monetary policy that is decided by monetary policy committee (MPC) of the Bank of England (BoE). The policy is set and announced by the MPC eight times a year (The Bank of England, 2019). Hence, changes in the macroeconomic conditions can directly affect the monetary policy decisions in the UK. For example, in the case of excessive inflation in the UK, the MPC may decide to increase the interest rates in order to decrease the inflation through decreased money supply. Contrarily, the ECB does not make decisions based on a single country. The monetary policy in the UK is affected by its economic growth and employment levels as well. However, the impact of monetary policy may take two years before the full effect can be observed. The inflation target in the UK is 2% with the aim of keeping the annual rate of CPI not more or less than 1% from the target. In the case of the actual inflation differing more than 1% from the target, the BoE must give the government the reasons for why that has happened and how it aims to reach the target level. The main instruments that the BoE utilizes are QE and changing the bank rate. The QE is usually implemented when the interest rates are close to zero. For example, due to the 2008 financial crisis, the BoE adopted QE and created £375bn pounds during the years 2009-2012. Moreover, in 2016, due to the Brexit uncertainty, the BoE bought £60bn worth of UK government bonds as well as £10bn worth of corporate bonds (BBC News, 2020).

In the case of Finland, it is part of the Euro-system which includes the national central banks of the countries that are part of the Eurozone. The Bank of Finland takes part in preparing the euro area single monetary policy. Similar to the UK, the inflation target set by the ECB is 2% or just below (Suomen Pankki, 2020). Hence, price stability being the main objective, the aim is to keep annual rate of inflation within the target and safeguard the purchasing power of the euro. The monetary policy in the Eurozone is conducted by using operational implementation framework. The framework consists of standing facilities, market operations, and the minimum reserve requirements. Standing facilities consists of marginal lending facility and the deposit facility. In order to increase/decrease liquidity, the ECB offers these facilities to its counterparties. The counterparties use the lending facility to borrow money against a collateral. Likewise, the deposit facility is for the counterparties to make deposits. Both operations are conducted on overnight basis. The market operations are concerned with monetary policy communication and liquidity management. The minimum reserve requirement is compulsory for all the credit institutions in the Eurozone. This is a certain portion of the deposit portfolios of these institutions that is kept at the national banks of each country. In addition to these, the ECB also uses asset purchase programmes that became important due to the financial crisis. These programmes allow for securities purchases as the short-term interest rate operations have been insufficient. For example, the ECB implemented QE in 2015 by pumping $600bn to the Eurozone (BBC News, 2020).

It is apparent that in the UK monetary policy can be altered according to the economic needs. However, in the case of excessive inflation in Finland, for example, the ECB would most probably restrain from increasing the interest rates if other members are not having the same problem. Hence, the monetary policy cannot react to economic needs of Finland alone. There is an advantage to this as many times increased governments restrain from adopting fiscal policy in order to keep price stability. Hence, this makes the expansionary fiscal policy more effective in the Eurozone as increased government spending would not cause increased interest rates. For both the central banks, the most significant aim of the monetary policy is price stability.

2.1.7 Asset price theories and monetary policy

The theories concerning the asset returns and monetary policy are connected to each other via three main channels: interest rate, credit and risk premium. These channels, in turn, have wealth and balance sheet effects (Ioannidis and Kontonikas, 2008). While the wealth effect refers to the changes in consumption, the balance sheet effect refers to the changes in investment. When a central bank changes the nominal rate, this influences the risk premium through the cost of leverage. Lower nominal rates (expansionary monetary policy) suggest that the liquidity gets cheaper, increasing the leverage and decreasing the risk premium. As a result, asset prices increase. However, as apparent from equation (2), the decreased risk premium would also decrease the expected returns. This, in turn, would gradually decrease the stock prices to their natural level as the monetary shock has been neutralised in the long run. Contrarily, when the nominal rates are increased, the liquidity is costlier, and as a result leverage decreases and the risk premium increases. The local risk premium is affected if the asset is even partially affected by the local asset pricing. As per the theory, monetary policy affects the asset prices (or stock prices) through changes in risk premium that investors ask for as a compensation to the risk they are taking. This relates to the discounted cash flow model which also plays a significant role in this analysis. As the contractionary monetary policy is conducted, the demand for loans decreases due to increased interest rates (higher costs of borrowing). As a result, consumption and investment decrease, causing a decrease in stock prices through lower investment and consumption.

2.2 Empirical Literature Review

Many papers in the past have visited the predictability of stock returns. The question of whether we could predict the movements in stock prices to some degree is very prevalent even today. The earliest works in the literature focus on proving the constant expected returns (CER) hypothesis that states the returns of an asset to be normally distributed with constant mean and variance, and they are independent over time. However, many papers have proved that the stock returns are time-varying and predictable. Fama and French (1989, 1988) have used long-horizon tests, Shiller (1981) has used variance tests, Poterba and Summers (1998) have used variance ratios, Campbell (1991) has used short-horizon vector autoregression (VAR) model, and Lo and MacKinlay (1990) have used contrarian strategies – all of these have proven to some degree that the stock returns can be predicted.

Patelis (1997) looks at how the changes in monetary policy affect the predictability of stock returns. He uses the NYSE value-weighted excess stock returns in monthly frequency as the dependent variable and various monetary policy indicators as independent variables. These indicators are the federal funds rate, spread between the federal funds rate and the ten-year Treasury note yield, the quantity of non-borrowed reserves, and the portion of its growth that is independent of the total reserve growth, and the spread between the six-month commercial paper and six-month T-Bills yield. The author also uses other financial variables such as the dividend yield, the one-month real interest rate and the spread between ten-year government bond yield, and one-month T-Bill yield. The author finds through long-horizon regressions and short-horizon VARs that monetary policy variables can predict excess stock returns. Contractionary monetary policy seems to predict initial lower expected returns, followed by higher returns later. The results of variance decompositions imply that the expected excess returns and expected dividend growth are more affected by monetary policy than expected real returns that see a minor effect. Other financial instruments also prove to be significant, which indicates that monetary policy is not the only variable predicting the stock returns. Interestingly, the paper finds dividend yield to be the most dominant factor in predicting future expected asset returns indicating that the persistence of expected asset returns is much higher than other macroeconomic business cycle variables.

To see how monetary policy shocks affect the stock prices, Li et al. (2010) use the data from Canada and the United States. They use structural VAR models and apply short-run restrictions that are appropriate for both countries. The paper focuses on two main economic components – trade and market openness. According to the paper, Canada represents a small open economy, whereas the US represents a large, relatively closed economy. The time-period for the dataset is January 1988 to December 2003. For stock prices, the S&P 500 index is used for the US, and the TSE 300 index is used for Canada. The indexes are normalized by the consumer price index to represent the values in real terms. For the US markets, the SVAR model contains real output, the money supply, the price level, the price of oil, and the federal funds rate. As for the Canadian markets, the VAR model consists of real output, the money supply, the price level, the bilateral nominal exchange rate between the US and Canada, the federal funds rate, and the overnight interest. These variables are included in the models as the study uses the general equilibrium framework, where the macroeconomic variables are in continuous interaction over time. For both countries, stock prices are used to control for the effects of wealth (Li et al., 2010). Excluding interest rates, all the variables are in their logarithmic forms. The Schwartz and Akaike criteria and log-likelihood function values are used for model selection for the empirical model of Canada. With the use of the methods mentioned above, the authors find that the effects of monetary policy are much more significant for the US than Canada. For example, an unanticipated increase of 25 basis points in interest rates decreases the stock price in the US by 4%. However, the effect on the stock prices in Canada is far less with only a 0.8% decrease. The effect of the shock is highest for the first month as it gradually decreases as the time goes by.

Other papers using VARs include Park and Ratti (2000) and Thorbecke (1997). The research by Thorbecke (1997) indicates that the effect of a 1% unexpected increase in the federal funds rate, decreases the stock prices by 0.8%. Rigobon and Sack (2004), however, use the heteroscedasticity approach. They look at the response of equity returns on monetary policy shocks in the US using particular dates – days of FOMC meetings and the Chairman's semi-annual testimony to Congress regarding the monetary policy. The stock index data in the study includes Dow Jones Industrial Average (DJIA), Nasdaq, the Wilshire 5000, and the S&P 500 with the sample period of January 3, 1994, to November 26, 2001. The proxies for the long-term interest rates are Treasury yields with different maturities (six months, one, two, five, ten, and thirty years). Rigobon and Sack (2004) use the Eurodollar futures rate to account for the short-and intermediate interest rate responses. The strategy that the paper uses is the identification through heteroscedasticity, which looks at how interest rates and asset prices collectively react when it is known that a shock in the system is going to shift. Hence, very weak assumptions can be made for the analysis of the change in asset prices. This method is then used by implementing instrumental variables and generalized method of moments (GMM). The results of the research reveal that as the short-term interest rate is increased, the stock prices decrease. The most substantial effect can be seen on the Nasdaq index. As the short-term (three months) interest rate increases by 25 basis points, stock prices decrease by 2.4% when using the Nasdaq index and by 1.7% when using the S&P 500 index. Another paper that uses the heteroscedasticity approach is by Corallo (2006), which looks at the UK and Germany markets. Like in the research by Rigobon and Sack (2004), the results indicate that the unanticipated increase in the interest rates decrease the equity prices.

Gürkaynak, Sack, and Swanson (2005) study the effects of monetary policy on stock prices in the US by using high-frequency event-study analysis. They focus on the single factor for the analysis, which is the federal funds rate target. The announcements and decisions of the Federal Open Market Committee (FOMC) are the central focus of the paper. The monetary policy announcements from January 1990 to May 2004 are used. The authors study the announcements of the FOMC and determine the surprise component in them that causes the change in the federal funds rate. They use the surprise component as they assume that the expected monetary policy changes should have little or no impact on the financial markets and using the raw federal funds rate would yield errors. Hence, they use surprise changes as the independent variable of the model. The measure for the stock prices in the paper is the S&P 500 index. The authors use the standard linear regression method (Ordinary Least Squares) to conduct the tests. The results indicate that the unexpected change in the federal funds rate by 25 basis points, decreases the stock index by 1%. When the effects of employment reports and other news are excluded, the results indicate a more significant relationship. Interestingly, the authors find that the federal funds rate announcements are not the most significant factor. They find that the current federal funds rate target and the future path of policy have a more significant effect.

To determine how different macroeconomic variables affect aggregate stock market volatility, Paye (2012) uses Granger causality test. The paper uses out of sample econometric approach for the analysis. The in-sample results are used for reference and comparison. The emphasis is also on the analysis of the accuracy of out of sample forecasts in the case of volatility models that incorporate macroeconomic variables. The macroeconomic variables chosen for the analysis are changes in bank leverage, consumption to wealth ratio, commercial paper to treasury spread, default return spread, expected return, current and expected GDP growth, investment-capital ratio, volatility of growth in industrial production, net pay-out, volatility of inflation growth, and term spread. For the stock prices, the paper uses S&P500 index. All the variables are from the US economy. The results indicate through out-of-sample Granger causality that many variables such as commercial paper to Treasury spread, default return, default spread, and the investment to capital ratio can be used to forecast volatility. It is discovered in the paper that macroeconomic variables contain information that can be used to measure volatility and macroeconomic uncertainty.

The paper that is closely followed by this thesis is by Bjørnland and Leitemo (2009). The paper observes the effect of monetary policy on stock prices using the structural vector autoregression approach. They use the time-period of 1983-2002 at a monthly frequency. The federal funds rate is used to account for monetary policy, whereas S&P500 index is used to account for stock prices. Other variables used in the model are industrial production, consumer prices, and commodity price index. All the variables, except federal funds rate, are used in their logarithmic forms. Bjørnland and Leitemo (2009) find there to be a strong influence of monetary policy on stock prices as 100 basis points increase in the federal funds rate, causes a decline of 7-9% in stock prices. The change in the federal funds rate is measured as a monetary policy shock.

Following Bjørnland and Leitemo (2009), Kontonikas & Zivile Zekaite (2018) use SVAR methodology to study the effects of monetary policy on stock prices in the USA. They impose some short-run restrictions as well as one long-run restriction of monetary neutrality. The federal funds rate is used as a proxy for monetary policy, whereas S&P500 index is the proxy for stock prices. They use macroeconomic variables such as the output gap, annual inflation and annual changes in the Conference Board Leading Economic Index (CBLEI). The CBLEI is used to account for the future expectations relating to the economic activity in the USA. The output gap is obtained by utilising the deviation of the actual industrial production from its potential level where the industrial production is filtered by the Hodrick-Prescott decomposition to obtain the potential level. To obtain the annual inflation, the annual change in the CPI is used in its logarithmic form. Moreover, a dummy variable of financial crisis is included in the model as an exogenous variable. The serial correlation and heteroscedasticity tests are conducted as diagnostic tests. The findings of the paper indicate that a contractionary monetary policy has statistically significant negative effect on real stock prices. As the federal funds rate unexpectedly increases by 1%, the stock prices fall by 8%. After the shock, the effect stays statistically significant for two months. The findings are in line with other authors such as Thorbecke (1997), and Bjørnland and Leitemo (2009).

Studies of the topic in the context of Eurozone have been conducted by various researchers such as Altavilla, Brugnolini, Gürkaynak, and Motto (2019); Kholodilin, Montagnoli, Napolitano, Siliverstovs (2009); and Ioannidis and Kontonikas (2008). Altavilla et al. (2019) construct a database for their event-study to measure the impact of ECB's monetary policy on sovereign yields, exchange rates, and stock prices. They focus on monetary policy surprises by separately studying the press conference and press release windows and extracting conventional as well as unconventional monetary policy communication surprises. The paper also utilizes the market-based identification of QE and find that the QE narrowed the spreads. It also accounts for the financial crisis of 2008, and run separate regressions up to 2008, between 2008-2014 and 2014-2018. The findings show that monetary policy has a significant effect on stock prices. Lower interest rates indicate higher stock returns and vice versa. As for Kholodilin et al. (2009), they use the heteroscedasticity approach and a sector view to determine the relationship between ECB's monetary policy and stock market. They use 1-month EURIBOR rates to account for monetary policy; aggregate as well as the sectoral stock indexes are used to account for stock prices. These sectoral indexes are classified by the industry classification benchmark. The findings indicate that as the interest rate increases by 25 basis points, the stock market range decreases between 0.3-2.0% on the day that the monetary shock is announced publicly. When using the aggregate measures, the decrease in stock market range is about 1.0%. Ioannidis and Kontonikas (2008), on the other hand, consider 13 OECD countries including Finland and the UK in their analysis of monetary policy and stock prices. They find that the expansionary monetary policy increased stock prices—an average stock return being 1.77% in Finland during this period. Similarly, during the contractionary monetary policy, the stock prices are lower. While the UK was one of the countries with highest return differences. Monetary policy in the UK explains 3-8% of the variation in stock returns according to the results. For both –Finland the UK—the monetary policy was observed to have a statistically significant effect on stock returns. Hence, the monetary policy information is concluded to be useful in forecasting stock returns in these countries.

To study the effect of monetary policy on stock prices in the UK, Bredin, Hyde, Nitzsche and O'reilly (2007) look at the relationship between monetary policy and stock prices in the UK. They use different methods such as variance decompositions and the OLS event study method. The main findings indicate that the effect monetary policy has on stock returns is highly significant for the industrial level returns. Hence, the sensitivity to the stock market is dependent on the industry. These results apply for both variance decompositions and event study. The negative effects of monetary policy are especially apparent in the traditional industries such as oil and gas, steel, and automobile-parts. Belke and Beckmann (2014) also study the topic for the UK among other countries and use the cointegrated VAR (CVAR) approach. However, they do not find monetary policy to have significant effects on stock prices.

The empirical literature on the topic is vast and involves many different methods. However, one thing seems to be the same in most papers – the results. Most of the papers find that as the interest rates set by the central banks rise, stock prices tend to decrease. These findings are in line with the theory as according to the theory, increased interest rates decrease the money supply, decreasing the leverage available to investors, which causes lesser investments and decreasing asset prices. Most of the papers use the VAR methods to study the relationship. There are some papers that use different methods: Gürkaynak et al. (2005) use the OLS method, Rigobon and Sack (2004) use the heteroscedasticity approach, and Patelis (1997) uses the long-horizon regressions.

2.2.1 Empirical Literature Summary

Authors	**Country/ Countries**	**Time-Period/ Data Frequency**	**Variables**	**Model**
Patelis (1997)	USA	1962-1994/ Monthly	Federal funds rate, spread between the federal funds rate and the ten-year Treasury note yield, the quantity of non-borrowed reserves, and the portion of its growth that is independent of the total reserve growth, and the spread between the six-mint commercial paper and six-month T-Bills yield	Long-horizon regression and short-horizon VAR

Thorbecke (1997)	USA	1967-1990/ Monthly	Federal funds rate, industrial production, inflation rate, commodity price index (log), unborrowed reserves (log), total reserves (log), and stock returns for 22 industries	VAR, generalized method of moments, event study, non-linear regression estimation
Rigobon & Sack (2004)	USA	1994-2001/ Daily	Stock indexes, treasury yields, Eurodollar futures rates	Event study trough heteroscedasticity and GMM
Gürkaynak, Sack, and Swanson (2005)	USA	1990-2004/ Monthly	Federal funds rate, surprise component using FOMC announcements, S&P500 index,	Linear regression method (OLS)
Corallo (2006)	UK and Germany	1987-2003/ Daily	FTSE250, DAX100, government bond, corporate bond yield, exchange rates against dollar	VAR, Event study, Heteroscedasticity approach
Bredin, Hyde, Nitzsche and O'reilly (2007)	The UK	1993-2004 and 1975-2004/Daily and monthly	Sectoral stock returns, the market excess return, the real interest rate, the dividend price ratio (log), the 1-month change in the short rate (treasury bill), the spread between the 20-year government bond rate and the short rate, and the effective exchange rate.	Event study and Variance decomposition
Ioannidis and Kontonikas (2008)	13 OECD countries including Finland and the UK	1972-2002/ Monthly	ECB refinancing rate, equity returns, dividends, monetary policy changes	OLS using the Heteroscedasticity

Bjørnland and Leitemo (2009)	USA	1983-2002/ Monthly	Consumer prices, industrial production (log), federal funds rate, S&P500 (logs) commodity price index (logs)	Structural VAR
Kholodilin, Montagnoli, Napolitano, and Siliverstovs (2009)	Eurozone	1999-2008/ Daily	1-month EURIBOR, aggregate and ICB classified sectoral stock indexes	OLS using the Heteroscedasticity Approach
Li, İşcan, and Xu (2010)	Canada and USA	1988-2003/ Monthly	S&P500, TSE300, real output, money supply, price level, bilateral nominal exchange between USA and Canada, price of oil, federal funds rate (all variables in logs except interest rates)	Structural VAR
Paye (2012)	USA	1952-2010/Quarterly and Monthly	S&P500 index, bank leverage, consumption to wealth ratio, commercial paper to treasury spread, expected return, GDP growth, investment-capital ratio, industrial production, net pay-out, inflation, term spread	Granger Causality
Belke and Beckmann (2015)	USA, Japan, the UK, Australia, South Korea, Thailand, Brazil, Euro area	1983-2013/ Monthly and Quarterly	Broad money index, stock market indices, real GDP and the inflation rate, short and long-term interest rates (represented by money market rates), the 10-year government bond yield	CVAR
Kontonikas and Zekaite (2018)	USA	1994-2007/ Monthly	The output gap, S&P500 index, annual inflation, annual changes in the leading economic indicator	SVAR

Altavilla, Brugnolini, Gürkaynak, and Motto (2019)	Eurozone	2008-2018/ Intraday Data	Monetary policy target, forward guidance, QE, sovereign yields, exchange rates, and stock prices	Event study method using OLS

Table 2. 1 Summary of Empirical Literature: This table resents the summary of the most relevant empirical literature discussed earlier. It contains the basic information about the variables and methods some of the authors have used.

2.3 Gaps in literature

Although, the effect of monetary policy on asset returns is a widely researched topic, there are no papers that would compare the Finnish markets with the UK markets. More importantly, there are no published papers considering Finland particularly for this analysis apart from it being among a group of other countries. In addition, the time-period of 2001-2018 has not been used before.

3. Methodology

The purpose of this section is to present the methodology of the thesis. The methodology adopted is encouraged by the available literature and previously used methods. The section includes the research model, sample selection and data sources, the hypotheses to be tested, and the details of the Vector Autoregression (VAR) model and Structural VAR model. Moreover, endogeneity, autocorrelation and diagnostic tests are also discussed in this section. The data sources and sample selection include the sample periods, data frequency, and the data sources with justification of the sources. The hypotheses of the thesis are also presented to clarify how the research question is answered. As apparent from the literature review, in most of the previous research, VARs (Park and Ratti, 2000; Thorbecke, 1997; Li et al. 2010; Patelis, 1997) and regression methods (Patelis, 1997) are adapted. In addition to the chosen research methods, the data will be tested for stationarity, autocorrelation and stability.

3.1 The Research Model

To see how monetary policy and different macroeconomic variables affect the stock prices in the UK and Finland, the following basic research model is conducted:

$$\log PS_t = \alpha_0 + \beta_1 MP_t + \beta_2 logINF_t + \beta_3 logCP_t + \beta_4 logIP_t + \beta_5 FINCR_t + \varepsilon_t \tag{3}$$

where PS_t is the stock price index (London Stock Exchange for the UK and Helsinki Stock Exchange for Finland), MP_t is the variable accounting for monetary policy (Bank rate for the UK and the European Central Bank lending rate for Finland), INF_t accounts for the price levels with the use of consumer price index, CP_t represents commodity prices, IP_t is industrial production that accounts for output levels, and $FINCR_t$ is a dummy used to account for the financial crisis of 2008. The main variable for the analysis is evidently monetary policy. Excluding the dummy variable, all of the other variables act as controls to account for the business cycle effects (Hau and Lai, 2016). Moreover, all the variables, except the monetary policy variable (interest rate), are used in their logarithmic form to minimize heteroscedasticity (unequal variance in residuals) following Bjørnland and Leitemo (2009), and Kontonikas and Zekaite (2018).

3.2 Variable Descriptions

Stock Prices Indices: As a proxy for stock prices, the stock indexes in logs for both the countries are used (Bjørnland and Leitemo, 2009; Rigobon and Sack, 2004; Corallo, 2006). The OMXH25 consists of 25 of the most traded stocks in the Helsinki Stock Exchange. Likewise, the proxy for stock prices in the UK is the FTSE100 that contains the 100 most traded stocks in the London Stock Exchange. Full list of the companies on both the indexes are provided in the Appendix A. Stock prices are utilized in real terms by deflating them with the use of consumer price indices.

Monetary Policy: The proxy for monetary policy in the UK is the bank rate which is the interest rate set by the MPC. It is the most important rate as it determines the interest rate that is charged by the BoE when lending to banks in the UK. Hence, it is an adequate measure for monetary policy changes. As for Finland, the monetary policy is represented by the refinancing operations (MRO) rate set by the ECB (Ioannidis and Kontonikas, 2008). The MRO rate is the Eurozone equivalent of the bank rate as it is also set every six weeks and is used when European banks borrow from the ECB. Hence, it indicates the monetary policy set by the ECB.

Inflation: Inflation is known to influence stock prices as well as interest rates (Thorbecke, 1997). As a proxy for inflation the Consumer Price Index of both the countries has been used (Bjørnland and Leitemo, 2009). The CPI is calculated by using a consumer basket that contains the essential goods and services such as food, medical care and transportations, and their costs. Hence, the costs of the contents in the basked are averaged, obtaining a weighted average of the prices. The CPI is obtained by the following formula:

$$CPI_t = \frac{Market\ Basket\ Cost_a}{Market\ Basket\ Cost_b} * 100 \tag{4}$$

where the Market Basket Cost$_a$ denotes the cost of the basket in the present year, while Market Basket Cost$_b$ is the value of goods and services in the base year (Krugman and Wells, 2013). In this thesis the base year is 2000 for both the countries.

Commodity Prices: Thorbecke (1997) points out that monetary tightening, counterintuitively, increases the inflation in impulse response functions of the structural VAR models. This causes the price puzzle. Hence, the monetary policy may contain some information about inflation that is not included in the model. Specifically, if monetary policy is implemented to target an inflation indicator, it may then affect the inflation with a lag, causing higher inflation in the future, even though the policy is contractionary. To remedy this problem, Thorbecke (1997) suggests including the commodity price index in the VAR models as that would act as an additional inflation indicator. Hence, this would eliminate the price puzzle, making inflation decrease when contractionary monetary policy is implemented.

Industrial Production: To account for the real activity of the economies, industrial production is included in the model (Thorbecke, 1997; Bjørnland and Leitemo, 2009; Paye, 2012). Because many macroeconomic variables such as gross domestic product growth, consumption-wealth ratio, and investment-capital ratio are not available in monthly frequency, industrial production is implemented as a measure for economic activity (Paye, 2012).

Financial Crisis: The dummy variable of the financial crisis takes the value of one between the years 2007-2009 and is set to zero rest of the time. This variable is included in the SVAR model as an exogenous variable (Kontonikas and Zekaite, 2018). During the time of the financial crisis, many central banks had to suddenly opt for expansionary monetary policy in order to rescue the economy. Hence, not including this dummy variable may result in unrealistic results.

3.3 Sample Selection and Data Sources

The data type that is chosen for the thesis is time-series secondary data. The frequency of the data is monthly. All of the data for chosen variables is readily available in monthly frequency. The stock market index data for the London Stock Exchange (FTSE 100 in its closing prices) is obtained from the Yahoo! Finance. The data for the Helsinki Stock exchange (OMXH 25 in its closing prices) is obtained from Nasdaq. The data for CPI and commodity prices for the UK is obtained from the Federal Reserve Bank. The industrial production data is obtained from the Federal Reserve[2]. The data for CPI and commodity prices in Finland is obtained from the Statistics Finland database. The data available to the public by the Bank of England is used to obtain the data for the bank rate in the UK. As for Finland, the refinancing operations rate data is collected from the European Central Bank database. All the sources listed above are reliable and up to date. However, there are alternative sources to some of the variables that are cross-checked to account for any differences or potential errors. The time period selected for the research sample is from January 1, 2003, to December 31, 2018. The software used to conduct the research is EViews as it allows for the combination of short-run and long-run restrictions to be applied on the SVAR model.

3.4 Hypotheses to be tested

The main hypotheses for the research are regarding the effect of monetary policy on stock prices. The hypotheses for the UK are the following:

Null Hypothesis: Money supply does not have a statistically significant effect on stock prices in the UK. H_0: $\beta_1 = 0$

Alternative Hypothesis: Money supply has a statistically significant effect on stock prices in the UK. H_{11}: $\beta_1 > 0$

[2] Applies to both the UK and Finland

The hypotheses for Finland are as follows:

Null Hypothesis: Money supply does not have a statistically significant effect on stock prices in Finland. H_0: $\beta_1 = 0$

Alternative Hypothesis: Money supply has a statistically significant effect on stock prices in Finland. H_{11}: $\beta_1 > 0$

All the hypotheses for the research question and diagnostic tests are tested at 95% level of significance. Hence, if the probability of a result is less than 0.05, the null hypotheses is rejected.

3.5 Stationarity

To conduct the research using vector autoregression models, the variables need to be stationary. A non-stationary series can lead the population (co)variances to be ill-defined. Hence, the sample (co)variances do not converge to population (co)variances as the sample size grows. In a chosen model, a certain sample is used, however, it is important that this sample can represent the population for consistency. In terms of the variables, stationarity implies that for each lag, the mean, variance, and autocovariances of the variable are constant. In the case of series being stationary, the shocks that effect the system dissipate gradually. On the other hand, for non-stationary series shocks affect series infinitely across all time periods (Brooks, 2008) which is unrealistic for economic analysis. Non-stationary series have a risk of leading to spurious regressions that make the results seem significant and reliable when the actual regression is of no value. For example, a spurious regression may yield a high R^2 value which is an indicator of how much of the variance in a dependent variable can be explained by the independent variable. Hence, a high R^2 value is desirable, however, due to the regression being spurious, the obtained value is misleading. This leads to the standard asymptotic analysis assumptions to be invalid, and the t-tests and F-tests cannot be trusted.

To test for stationarity in the variables, the augmented Dickey-Fuller test is conducted for each variable separately. The null hypothesis of the test states that the variable has a unit root (it is non-stationary), while the alternative hypothesis suggests that there is no unit root (the series is stationary). The obtained test statistic must be of a smaller value than the critical value for the rejection of the null hypothesis. To remedy non-stationarity, the variables can be differenced. When a variable is stationary at first difference, it is I(1). However, if the variable is stationary without differencing it is stationary at level which is denoted by I(0).

3.6 Endogeneity

Although monetary policy may have significant effects on stock prices, the identification of the monetary policy impact is challenging. The reason for this is that stock prices may endogenously affect monetary policy decisions. Monetary policy expectations may result in stock prices influencing the interest rates. Moreover, the omitted variable bias can also occur in these kinds of simplified models. Omitted variable bias is a result of not including variables in the model that may influence both sock prices and monetary policy such as macroeconomic variables, and variables that contain information about changes in risk preferences of the investors (Rigobon and Sack, 2004). Due to these problems, the standard ordinary least squares estimation techniques are not consistent. There may be a correlation between regressors and the error term. Following equations demonstrate the problem:

$$\Delta ir_t = \beta \Delta sp_t + \gamma q_t + \varepsilon_t \tag{5}$$

$$\Delta sp_t = \alpha \Delta ir_t + q_t + \eta_t \tag{6}$$

where the change in interest rates is denoted by Δir_t , Δsp_t is the change in stock prices, and q_t accounts for a set of variables. Variable α shows the impact of the interest rate (monetary policy) on stock prices. Monetary policy shock is denoted by ε_t , while η_t is the shock to the stock prices. Running OLS regression on these variables would result in biased coefficient results as η_t is correlated with Δir_t due to stock prices affecting the interest rate with β (Rigobon and Sack, 2003). In addition, if some of the q_t variables are unobserved and not included in the model, it causes the omitted variable bias which is dependent on the value of γ. Therefore, the resulting OLS regression would be subject to both omitted variable bias and simultaneity bias. Hence, a methodology of simultaneous equations such as VAR is required as it is able to capture these dynamics (Rigobon and Sack, 2004).

3.7 Vector Autoregression Models

Due to the endogeneity problem described above, this thesis benefits from the vector autoregression models as recommended by previous literature. The ordinary least squares technique is known to deliver inconsistent results, especially when the time-period of the research is small (Hau and Lai, 2016). The VAR model is a multivariate time-series model that considers several series simultaneously (Verbeek, 2017). The VAR model states that each variable in the model must have its own equation and should be treated equally (Gujarati, 2011). Hence, all the variables in the model are treated as endogenous variables with an equal number of regressors. The model is especially useful when the history of one variable helps to explain the future variations in another variable. The multivariate time-series models require the variables in the model to be stationary.

A VAR model aims to describe changes in different variables resulting from the common history amongst them. For example, in the case of variables Y_t and X_t, the VAR yields two separate equations:

$$Y_t = \delta_1 + \theta_{11} Y_{t-1} + \theta_{12} X_{t-1} + \varepsilon_{1t} \tag{7}$$

$$X_t = \delta_2 + \theta_{21} Y_{t-1} + \theta_{22} X_{t-1} + \varepsilon_{2t} \tag{8}$$

where the two white noise processes ε_{1t} and ε_{2t} are independent of the history of Y and X. These white noise processes represent shocks or impulses. Both the equations notably only consider the lags of its own variable and the other variable. Hence, the present values are not included in the model. The VAR models are often named as VAR(p), where p is the number of lags in the model. The model can be extended for more variables (equations) and lags. According to the equations (7) and (8), the model is VAR (1). The matrix representation of the equations (7) and (8) is:

$$\begin{pmatrix} Y_t \\ X_t \end{pmatrix} = \begin{pmatrix} \delta_1 \\ \delta_2 \end{pmatrix} + \begin{pmatrix} \theta_{11} & \theta_{12} \\ \theta_{21} & \theta_{22} \end{pmatrix} \begin{pmatrix} Y_{t-1} \\ X_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \tag{9}$$

Even though error terms do not depend on the history of Y and X, they may be subject to correlation needs to be tested for (autocorrelation). In the case of θ_{12} being different from 0, history X is able to explain the variations in Y. The general VAR is denoted as:

$$Y = \delta + \Theta Y + \vec{\varepsilon} \tag{10}$$

Where each Θ denotes a k x k matrix and $\varepsilon^{\rightarrow}$ is k-dimensional vector of white noise terms with covariance matrix Σ. The advantages of the VAR mode include that it is able to produce more accurate forecasting as the information of another variables' history is incorporated. Moreover, the model may also have fever lags and still be parsimonious. Even though the VAR model is always identified, for policy analysis and structural inference, the structural VAR model is more accurate as it allows for the differentiation between correlation and causation.

3.8.1 Structural Vector Autoregression Model

The structural vector autoregression (also refer to as identified VAR) model is used in this thesis as the reduced form VAR model is not sufficient enough for policy implications of economic models (Bjørnland and Leitemo, 2009). The identification of the SVAR model concentrates on the linear combination of the external shocks that are derived from the errors in the system. Hence, it does not identify the autoregressive coefficients. The SVAR estimation is identical to estimating a simultaneous equation model with covariance restrictions. However, the main difference is that the SVAR model does not require as many restrictions for identification. The SVAR model requires restrictions that are just enough, and over-simplification is avoided. In this thesis, the identification is implemented through imposing short-run restrictions as well as a long-run restriction of monetary policy neutrality following Bjørnland and Leitemo (2009). Hence, the effects of monetary shocks are transitory, and they vanish in the course of time. The shocks are assumed to be related to the residuals due to them being independent of their past processes and being the input of a system (dynamic and linear) that generates the K-dimensional time-series vector denoted by y_t (Lütkepohl and Krätzig, 2007). The structural innovations need to be uncorrelated, and thus, be orthogonal. This is ensured via autocorrelation test of residuals. In the case of correlation, all the relationships between the shocks would have to be accounted for.

Following Kontonikas and Zekaite (2018), the SVAR model of this thesis can be presented as:

$$Q_t = [logIP_t, log\ INF_t, log\ CP_t, logPS_{t,}\ MP_t]' \tag{11}$$

where Q_t represents the (5x1) vector containing the macroeconomic variables of the chosen model. Assuming that the model is stationary and invertible, it can be represented as a moving average (MA) process:

$$Q_t = B(L)v_t \tag{12}$$

where B(L) = $\Sigma_{p=0}^{\infty} B_p L^p$ which makes it the (5x5) convergent matrix polynomial[3]. The vector (5x1) of reduced form residuals v_t is independently and identically distributed ($v_t \sim iid(0, \Omega)$. The covariance matrix Ω is assumed to be positive. The fundamental disturbances ε_t are the vector of structural shocks ordered as $\varepsilon_t = [\varepsilon_t^{IP}, \varepsilon_t^{INF}, \varepsilon_t^{CP}, \varepsilon_t^{PS}, \varepsilon_t^{MP}]$. In this equation MP and PS are the monetary policy shocks and stock price shocks respectively. The remaining shocks are left unidentified; however, they form their own equations. The structural disturbances ε_t are a linear combination of v_t. Here v_t=$J\varepsilon_t$, and J represents the contemporaneous matrix of (5x5). It is assumed that the vector of structural shocks has a variance-covariance matrix of $\Sigma_\varepsilon = E(\varepsilon_t \varepsilon_t^{'})$ and the structural shocks are uncorrelated with a zero mean. The n-variable, p-order SVAR model can be presented as (Kontonikas and Zekaite, 2018):

$$B_0 Q_t = B_1 Q_{t-1} + B_1 Q_{t-2} + \cdots - B_p Q_{p-1} + \varepsilon_t \tag{13}$$

[3] $B(L) = B_0 - B_1 L - B_2 L^2 - \cdots - B_p L^p$ (Kontonikas and Zekaite, 2018)

To represent the model with long-run restrictions, the SVAR model must be of the vector moving average (VMA) form:

$$Q_t = B(L)^{-1}\varepsilon_t \tag{14}$$

Which can be written as

$$Q_t = C(L)\varepsilon_t \tag{15}$$

This is the representation in terms of the structural disturbances. Here C(L) is the matrix of polynomial lags $C(L) = [C_{zj}(L)]$ for $z, j = 1, .., n.$. This can also be presented as follows:

$$C_{zj}(L) = \Sigma_{k=0}^{\infty} C_{iz}(k) \tag{16}$$

This equation demonstrates the structural shock in the variable j, and the response of variable z to that shock after k periods. The reduced form of the SVAR model needs to be derived as the OLS estimation is not possible for estimating the simultaneous relationship among endogenous variables. To obtain the reduced form, the equation $B(L)Q_t = \varepsilon_t$ must be multiplied by B_{0-1} to obtain $A(L)Q_t = v_t$, where

$$v_t = B_{0-1}\varepsilon_t \tag{17}$$

$$B_{0-1}B(L) = A(L) = I - A_1L - A_2L^2 - \cdots - A_pL^p \tag{18}$$

As assumptions of the SVAR model of constant variance-covariance matrix, zero mean and no serial correlation also apply for the reduced form residuals v_t, the stationary reduced-form model can have the VMA representation:

$$Q_t = A(L)^{-1}v_t = G(L)v_t \tag{19}$$

The long-run expression of the model takes the following form:

$$C(L)\varepsilon_t = G(L)B_0^{-1} \tag{20}$$

Where the $C(L)$ denotes the responses of the endogenous variables in the long run, and $G(L) = A(L)^{-1}$. The structural shocks are assumed to be normalised and orthogonal. Moreover, they are assumed to have a unit variance, where variance-covariance matrix is the identity matrix ($\Sigma_{\varepsilon} = I$). For identification purposes $\frac{n(n-1)}{2}$ restrictions must be placed on the structural model. These restrictions can be imposed on the matrix of long run responses $C(L)$, inverse of the contemporaneous matrix B_{0-1} , or both. In the structural model of this thesis, for complete identification, 25 restrictions must be placed. Fifteen of the restrictions come from the fact that the unit variance of structural shocks is assumed to be orthogonal. The remaining ten restrictions come from the equation $(n(n-1))/2$, where $n = 5$ which is the number of variables in the model. The restriction of no contemporaneous relationship between the variables in the short run is implemented by setting the adequate elements equal to zero in the matrix B_{0-1}. The matrix is obtained in the form as follows:

$$\begin{bmatrix} IP_t \\ INF_t \\ CP_t \\ PS_t \\ MP_t \end{bmatrix} = G(L) \begin{bmatrix} \beta_{11} & 0 & 0 & 0 & 0 \\ \beta_{21} & \beta_{22} & 0 & 0 & 0 \\ \beta_{31} & \beta_{32} & \beta_{33} & 0 & 0 \\ \beta_{41} & \beta_{42} & \beta_{43} & \beta_{44} & \beta_{45} \\ \beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & \beta_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{IP} \\ \varepsilon_t^{INF} \\ \varepsilon_t^{CP} \\ \varepsilon_t^{PS} \\ \varepsilon_t^{MP} \end{bmatrix} \tag{21}$$

As for the relationship between the variables, recursive restrictions have been applied. The macroeconomic variables (IP, INF, and CP) are placed before interest rates and stock prices to account for monetary policy having no contemporaneous effect on them. Conversely, monetary policy is allowed to respond to the macroeconomic variables. Moreover, in the fifth column of the matrix, three zero restrictions are placed to account for monetary policy not affecting commodity prices, inflation or industrial production. Similarly, the relationship between macroeconomic variables and stock prices is also defined by placing the restrictions in the fourth column. Hence, stock prices react to all the variables immediately (no zeros in the fourth row), while the macroeconomic variables respond with a lag (Bjørnland and Leitemo, 2009). Industrial production (IP) is assumed to not be simultaneously affected by any other variable in the model. Whereas, inflation is assumed to react to industrial production, and commodity prices are assumed to respond to both inflation and industrial production. As per the last two rows in the matrix, they indicate that there are no restrictions on the relationship between monetary policy and stock prices. As per the standard in the literature of the topic, it is often assumed that stock prices react with a lag to monetary policy, or that monetary policy reacts to the stock prices with a lag (stock prices are ordered below monetary policy). The latter case is plausible for examining the response of stock prices to monetary policy; however, this could cause a bias as a possibly relevant channel of interaction between monetary policy and stock prices could be ruled out. Hence, the identifying restriction of long-run monetary policy neutrality is imposed (Bjørnland and Leitemo, 2009). To do this, the infinite number of relevant lag coefficients are set to zero in the long-run matrix, $\Sigma_{k=0}^{\infty} C_{45}(k) = 0.$ Hence, the following equation is obtained:

$$G_{41}(1)\beta_{15} + G_{42}(1)\beta_{25} + G_{43}(1)\beta_{35} + G_{44}(1)\beta_{45} + G_{45}(1)\beta_{55} = 0 \tag{22}$$

The equation (22) follows from setting $C_{45}(1) = 0$. As the restriction above is imposed, the model becomes just identified. The parameters above the monetary policy rate that are set to a zero are identified through Cholesky restrictions, and the rest are identified with the long-run restriction. Hence, the monetary policy is allowed to have long-run effects on stock prices, while both stock prices and monetary policy are not allowed to have instantaneous effects on the macroeconomic variables.

3.9 Autocorrelation and Normality

Although, the VAR models are convenient for not having strict conditions upon them, they do require some diagnostic tests to ensure that they are adequate for the research. Most importantly, the model requires there to be no autocorrelation in residuals. Autocorrelation occurs when the error terms in the model are correlated with each other. Hence, the error term at time (t) is correlated to the error term at (t-1). This also applies when the error term is correlated with any past error term. Autocorrelation may result from the model not being specified correctly. Hence, to test for autocorrelation, this thesis benefits from the Breusch-Godfrey LM test. The Breusch-Godfrey test is illustrated by assuming that the error terms follow the structure (Brooks, 2008):

$$u_t = p_1 u_{t-1} + p_2 u_{t-2} + \cdots + p_p u_{t-p} + \varepsilon_t \tag{23}$$

where the residuals are denoted by u_t. Hence, equation (27) represents the autoregressive structure of an AR (p). In this structure, the lags of the past error terms until lag p affect the current error terms. The null hypotheses of the test are the following:

$$H_0 = p_1 = p_2 \dots = p_p = 0 \; (No\ Autocorrelation) \tag{24}$$

$$H_{11} = p_1 = p_2 \dots = p_p \neq 0 \; (Autocorrelation\ exists) \tag{25}$$

Hence, rejection of the null hypothesis would imply that there is autocorrelation in residuals. The Breusch-Godfrey LM test gives the probabilities of autocorrelation at different lags. The lag where no autocorrelation is present (the probability is higher than 0.05) is the optimal lag length for the model.

In addition to the autocorrelation test, Jarque-Bera test for normality is often recommended. Normality here means that the distribution of data follows the bell-shaped normal distribution. However, financial data is very rarely normally distributed. There are often extreme values in the data (Brooks, 2008). For example, in the case of stock prices, they may significantly decline within a day. However, with large samples such as in this thesis, normality test is not necessary. As per the central limit theorem, the distribution of large samples (larger than 40) is normal, even if the shape of the data indicates non-normality. Hence, the central limit theorem states that when the chosen sample is large enough, the mean of this sample would be approximately same as the mean of the population. The normality condition, therefore, can be ignored for large financial data samples. Another condition that VAR models need to satisfy is the stability condition, which is to be tested in this thesis. This condition implies that none of the inverse roots lie outside of the unit circle. If the stability condition is not satisfied, the VAR model yields unreliable results. Hence, it is important to test for the stability condition (Gujarati, 2011).

4. Results

This section presents all the results from the tests described earlier. Summary tables are used to display the most important findings with the most relevant figures. Complete set of tables and figures obtained from the software (EViews) can be found in the appendix A.1 (results concerning Finland) and A.2 (results concerning the UK). The results of stationarity and diagnostic tests are presented first as they need to be satisfied before running the structural vector autoregression model. To detect the effects of monetary policy on stock prices, the SVAR estimation results as well as impulse response functions are analysed and compared to the findings of the previous literature. The structure of this section is as follows. Firstly, results for Finland are presented. For each country, the results start with Augmented Dickey-Fuller stationarity test results, followed by the results for the lag length selection, autocorrelation and stability. Lastly, the results from SVAR model and impulse responses are shown with a discussion of the indication of the results. The results for the UK are then presented with the same structure.

4.1 Finland

4.1.1 Stationarity

To test for stationarity is conducted by using the Augmented Dickey-Fuller test. Firstly, the variables are presented in levels and tested for stationarity. In the case of non-stationarity, the variable is then transformed into its first difference form. The variable is then tested again. In general VAR models are best suited for models with I(0) or I(1) variables. The null hypothesis states that the variable is non-stationary. The following table presents the obtained results:

Variable	Obtained Statistic/Test Critical Value	Result	Obtained Statistic/Test Critical Value (First Difference)	Result
$logPS_t$	(-2.190) / (-2.8765)	Fail to Reject the null hypothesis	(-12.056) / (-2.8765)	Reject the null hypothesis
MP_t	(-1.482) / (2.8770)	Fail to Reject the null hypothesis	(-4.165) / (2.8770)	Reject the null hypothesis
$logCP_t$	(-1.328) / (-2.877)	Fail to Reject the null hypothesis	(-7.874) / (-2.877)	Reject the null hypothesis
$logINF_t$	(-1.604) / (-2.877)	Fail to Reject the null hypothesis	(-3.276) / (-2.877)	Reject the null hypothesis
$logIP_t$	(-1.956) / (-2.877)	Fail to Reject the null hypothesis	(-12.84) / (-2.877)	Reject the null hypothesis

Table 4. 1: Stationarity Finland Data: The results suggest that all the variables are I(1), hence, he VAR methodology can be used. The null hypothesis is rejected when the test statistic is more negative (smaller than) the critical value. All the variables are then transformed to the differenced form, obtaining the variables: $dlogPS_t, dMP_t, dlogCP_t, dlogINF_t, dlogIP_{t.}$

4.1.2 Lag-Length Selection, Autocorrelation and Stability

The lag-length criteria selected is the Akaike information criterion (AIC) as suggested by Brooks (2008). The test results are available in appendix A.1 (Table A.1.11). The appropriate lag-length is denoted by an asterisk (*) on the table. As apparent from the results, the optimal lag-length for the model is three. To further check the suitability of the model, autocorrelation test is conducted with the null hypothesis of no autocorrelation. The result is as follows:

Lag	Probability	Result
1	0.0834	Reject Null Hypothesis
2	0.0033	Reject Null Hypothesis
3	0.2698	Fail to Reject Null hypothesis

Table 4. 2: Autocorrelation Test Finland (Full Results: Table A.1.12)

As seen from the table, the null hypothesis cannot be rejected at lag three where probability is higher than 0.05 at 0.27. Hence, lag length of three is appropriate for the model as there is no autocorrelation present and it is supported by the AIC for optimal lag selection. The stability test result indicates that the model is stable, and the test results can be found in Appendix A.1 (Table A.1.13). With the use of all these tests, it can be concluded that the model is appropriate and there is no misspecification present.

4.1.3 SVAR and Impulse Response Functions

According to the results obtained by the SVAR model, monetary policy has a negative signficant effect on stock prices in Finland. The table A.1.14 in Appendix A.1 shows the full SVAR model results. The results of the estimation can be seen as long-run (F matrix) and short-run (S matrix) matrices. There is a long-run restriction of monetary neutrality imposed by setting the value of C (15), which denotes the effect of monetary policy on stock prices, to zero in the F matrix (long-run matrix). Other restrictions are imposed on the S matrix (short-run matrix). The SVAR estimation results can be seen on the matrices presented on the lower part of the table which show that monetary policy has a statistically significant effect on stock prices [C (15)] in the short run. The observed effect is negative (-0.001249) with the probability of zero. Hence, we can reject the null hypothesis that monetary policy does not have a statistically significant effect on stock prices in Finland. An increase in the refinancing rate (contractionary monetary policy) causes the percentage change in the stock prices to fall by 0.125%. This is in line with the theory that as the monetary policy is tightened, it decreases the money supply and the availability of money. These effects, in turn, decrease investment and cause the stock prices to decrease. The findings are similar to Kontonikas & Zivile Zekaite (2018); Bredin et al. (2007); Rigobon and Sack (2004) and Bjørnland and Leitemo (2009) who also find there to be a negative response of stock prices to monetary policy tightening (increase in interest rates). To further see the effects of monetary policy, the impulse responses are considered. The impulse response graphs show the effect of a monetary policy shock on the variables:

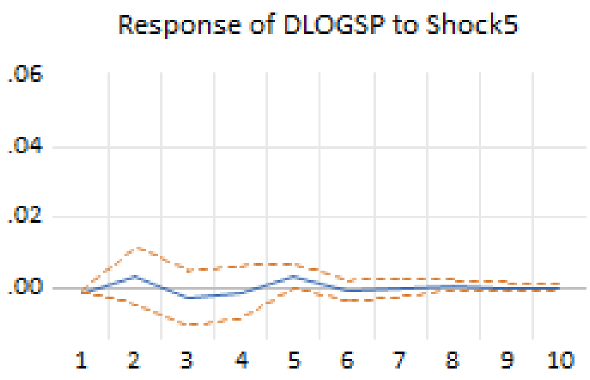

Figure 4. 1: Response of stock prices to the monetary policy shock (Finland)

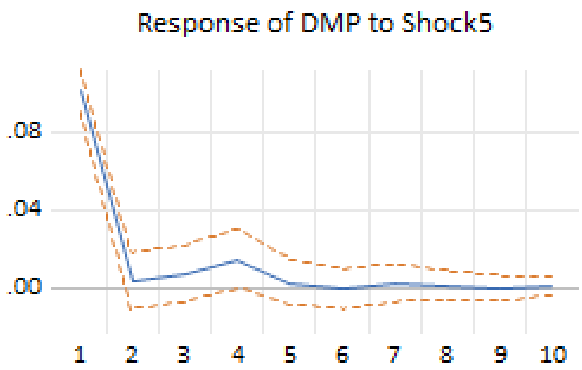

Figure 4. 2: Response of the refinancing rate to the monetary policy shock (Finland)

The monetary policy shock in the impulse response functions is denoted by shock 5 as it is the last variable in the ordering of the structural VAR model. The y-axis denotes the value of the effect, and the x-axis is the time period. As seen from the figure 4.1, a monetary policy shock has a very slight negative effect on stock prices (-0.001). However, in time period two, the stock prices tend to increase by 0.3%. The prices have a slight drop again in period three (-0.003). After having another peak in time period five (0.003), the stock prices tend to stabilize, and the effects of the shock tend to dissipate after period six. The response of the refinancing rate to the monetary policy shock shown in figure 4.2 is very different. There is a sharp increase initially in period one and a significant drop in period two. This result is very similar to the result detected by Kontonikas & Zivile Zekaite (2018) where the federal funds rate has a sharp initial increase as a response to the monetary policy shock. However, the effect seems to dissipate quickly which is also similar to the figure 4.2 of this thesis. Both the figures clearly show that whenever the monetary policy is tightened (increase in refinancing rate), stock prices tend to decrease. The effects of the monetary policy shock on the stock prices is negative, temporary and significant. It is important to note that the initial reaction of the stock prices is quite minimal. This could be a result of future expectations of the investors. However, these results need to be examined cautiously as there may be other factors affecting the stock prices. Through the identification of the SVAR model, this thesis has aimed to minimize the unobserved effects, however, they cannot be completely ruled out. Price puzzle is not present as impulse response of inflation to monetary shock seems to be intuitive (Table A.1.15, fifth column). As the contractionary monetary policy is imposed, the inflation seems to decrease which supports the argument that higher interest rates decrease the money supply, decreasing inflation. However, the effect is not large or statistically significant.

4.2 The UK

4.2.1 Stationarity

Table 4.3 shows the ADF stationarity test results for the UK. All of the variables are I(1) except for industrial production which is stationary at I(0) and does not require to be transformed to first difference. The variables after the transformations are:

$dlogPS_t, dMP_t, dlogCP_t, dlogINF_t, logIP_{t.}$

Variable	Obtained Statistic/Test Critical Value	Result	Obtained Statistic/Test Critical Value (1st Difference)	Result
$logPS_t$	(-1.232) / (-2.877)	Fail to Reject the null hypothesis	(-10.868) / (-2.877)	Reject the null hypothesis
MP_t	(-1.171) / (2.8770)	Fail to Reject the null hypothesis	(-4.425) / (2.8770)	Reject the null hypothesis
$logCP_t$	(-1.201) / (-2.877)	Fail to Reject the null hypothesis	(-6.863) / (-2.877)	Reject the null hypothesis
$logINF_t$	(-2.079) / (-2.877)	Fail to Reject the null hypothesis	(-11.278) / (-2.877)	Reject the null hypothesis
$logIP_t$	(-3.283) / (-2.877)	Reject the null hypothesis	N/A	N/A

Table 4. 3: Stationarity the UK Data (Null hypothesis of non-stationarity)

4.2.2 Lag-Length Selection, Autocorrelation and Stability

According to the AIC, the appropriate lag-length for the UK data is one lag. The results can be seen on table A.2.10. Similarly, the autocorrelation test results indicate that there is no autocorrelation at lag one or after (Table 4.4). Hence, the lag-length of one lag is appropriate for the model. Moreover, according to the stability test, the VAR model is stable with all the roots residing inside the unit circle. The test result can be found in appendix A.2 (table A.2.12).

Lag	Probability	Result
1	0.1164	Fail to Reject Null hypothesis
2	0.8272	Fail to Reject Null hypothesis
3	0.7735	Fail to Reject Null hypothesis

Table 4. 4: Autocorrelation Results the UK (Full Results: Table A.2.11)

4.2.3 SVAR and Impulse Response Functions

The results of the SVAR estimations are shown by table A.2.13 in appendix A.2. As per the results, monetary policy has a negative significant effect on stock prices. This result is again in line with the theory and the available literature. However, the effect is larger than for Finland at (-0.0266) with a probability of zero. Hence, an increase in the monetary policy causes a percentage change of (-2.7%) in stock prices. This is much larger than what was found in the case of Finland. One plausible reason for this may be the fact that the UK has an independent monetary policy. Hence, the changes in the policy variable would have a larger effect. In the case of Finland, monetary policy targets the entire eurozone, and Finland being a relatively small country, it may not be as sensitive to the changes in the financial markets as the UK. The findings support the results detected by Bredin et al. (2007) who studied the effects in the UK and found there to be a negative relationship. To further detect the effects of monetary policy shocks, the following impulse responses are obtained:

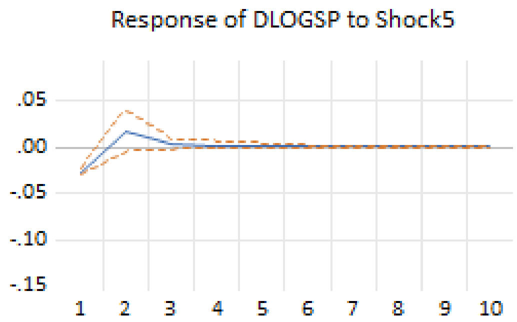

Figure 4. 3: Response of stock prices to the monetary policy shock (the UK)

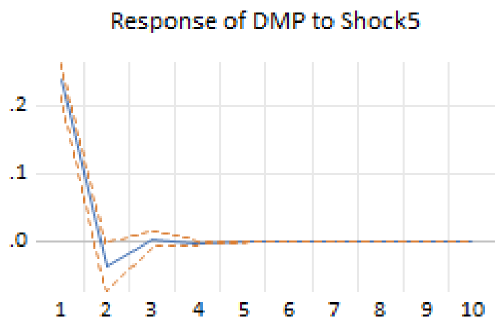

Figure 4. 4: Response of the Bank Rate to the monetary policy shock (the UK)

Figure 4.3 shows the reaction of stock prices to a monetary policy shock, while figure 4.4 represents the response of the bank rate the shock. The impulse responses are again very similar to the case of Finland. However, the effects are larger. The response of stock prices to the monetary policy shock is a drop of 2.4%. While the response of the bank rate is as high as 24%. In period two, there is a sharp decline to (-0.04) in the response of the bank rate to the monetary policy shock. Contrarily, the stock prices increase in period two (0.016). In the case of the UK, the monetary shock dissipates quickly after period three. The negative effect of the monetary policy tightening can be seen clearly as the stock prices decline while the bank rate increases sharply. When the bank rate drops, stock prices tend to increase. Hence, after an initial drop, stock prices increase in the later period which is supported by the findings of Patelis (1997). The effects of the monetary policy shock on the stock prices is negative, temporary and significant.

The results also seem to be consistent with the findings of Li et al. (2010), who find that the effects of monetary policy are smaller for a small open economy (Canada) than a large closed economy (USA). Even though, the UK is not considered a closed economy, it is interesting to see how smaller economies are less sensitive to monetary policy shocks. However, the results of this thesis show that the effects of a monetary policy shock last longer for Finland (small open economy) than for the UK. This is different to the findings of Li et al. (2010), who find that the dynamic response of the stock prices to the monetary shock in the USA (large closed economy) is prolonged. However, this difference could be related to the openness of an economy. According to Li et al. (2010) the differences are indeed due to the openness as stock prices of the USA significantly affect the stock prices in Canada, contributing to their volatility. The results found by Ioannidis and Kontonikas (2008) have also shown that the effect of a monetary policy shock is larger for the UK than Finland. Moreover, similar to the findings of this thesis, they find that contractionary monetary policy has a statistically significant negative effect on stock prices in both the countries. This negative effect can be related to the present value model (Ioannidis and Kontonikas, 2008) which states that as interest rate increases, discount rates increase, and future cash flows decrease. This, in turn, causes a decline in stock prices. Price puzzle is not present in the UK model (Table A.2.14, fifth column) as contractionary monetary policy does not increase inflation according to the impulse responses. As discovered with Finnish data, the effect on inflation is not large or statistically significant.

5. Conclusion

This section presents the conclusion of the thesis. It is comprised of the findings through the SVAR estimation and impulse responses, and limitations of the thesis. The section is structured as follows. The conclusion of the full thesis is presented first followed by the policy implications. Lastly, some limitations of this thesis are discussed with recommendations for the future research of the topic.

This thesis shows the response of stock prices to the monetary policy changes in two different economies: Finland and the UK. The research is conducted using structural vector autoregression approach which allows for short-run and long-run restrictions to be applied on the model. These restrictions are important for the policy implications of the results. Moreover, the SVAR approach allows for simultaneous equation estimation which is important for the model as there is often an endogeneity issue between monetary policy and stock prices. The model assumes there to be long-run neutrality for the response of stock prices to a monetary policy shock. Moreover, the short-run restrictions allow for macroeconomic variables to affect monetary policy and stock prices instantly, while the reaction of macroeconomic variables to the stock prices occurs with a lag.

The results indicate a statistically significant negative response of OMXH25 to the monetary policy changes made by the European Central Bank. However, the initial response is very minimal, and the changes tend to follow the changes in the ECB’s interest rate. One explanation for this could be that there are only 25 companies listed on the OMXH25 which may not give a complete picture of the reaction of other companies in Finland. However, the OMXH25 index contains the biggest companies, and the index is chosen as smaller companies may not be as sensitive to monetary policy changes as the bigger global companies. This is especially true for a small economy such as Finland. The response of FTSE100 to the changes in the interest rate set by the Bank of England is also significantly negative. However, the effect is much larger in the case of the UK than Finland. Both SVAR estimation result and impulse response functions of the UK indicate a bigger drop in stock prices as the monetary policy tightens. The effects of a monetary shock tend to dissipate quicker as well for the UK when compared to the case of Finland. It is difficult to determine, however, whether these differences are due to the different monetary policy channels or due to the difference in the size of the two economies. The companies in the UK may be more linked to the monetary policy as it is independent. Hence, the expectations of the investors about the macroeconomic variables and the interest changes may result in a stronger response. In the case of Finland, the monetary policy is not affected by the macroeconomic environment of Finland. Hence, the investors may not base their expectations solely on the macroeconomic environment of Finland and not respond as strongly.

5.1 Policy Implications

The results found in this thesis tend to be in line with monetary policy theory. It is detected that monetary policy is able to have a temporary effect on stock prices (Bjørnland and Leitemo, 2009). As stock prices are assumed to represent the business cycle as discussed earlier, it can be stated that monetary policy decisions do indeed affect the business cycle. The channel through with the policy works is most certainly the interest rate channel which affects the availability of money. However, it is not certain whether monetary policy could be useful for 'correcting' the price discrepancies in the stock market. Nonetheless, stock price tend to respond to monetary policy changes in an expected way. Because the stock prices are related to consumption as higher stock returns increase consumption, monetary policy could be beneficial in affecting the business cycle through stock prices.

5.2 Limitations and Suggestions for Future Research

Even though, the conclusion indicates that there is a statistically significant relationship between monetary policy and stock prices in both countries, these results need to be interpreted with caution. The SVAR approach is recommended by most authors for this study, however, there are few short comings of the approach. The interpretation of the relationship is heavily dependent on the analysis of impulse responses which may not yield precise results. The findings can be quite vague when compared to other methods. Moreover, in this thesis, heteroscedasticity (unequal variance in residuals) is present in the model due to the monetary policy variables of both countries. There are some extreme values in the monetary policy variable that are a result of radical changes in financial markets such as the financial crisis of 2008. However, the heteroscedasticity has been minimized in this thesis through the logarithmic transformation of macroeconomic variables and stock prices indices, and inclusion of a dummy variable of financial crisis. Moreover, because there is no autocorrelation or stability problems, the model is concluded to be adequate for the analysis (Brooks, 2008). To improve the results further, the model would benefit from a larger dataset with longer time-period and an inclusion of more variables. Due to the shortage of financial data availability without costs, this thesis was not able to benefit from a large dataset. Moreover, separating the smaller company stock prices from larger companies would also give interesting and more precise results.

Future research of the topic would benefit from a larger dataset that satisfies the normality and heteroscedasticity conditions. Moreover, inclusion of the year 2020 would yield very interesting results. This is because year 2020 has seen very extreme changes in stock prices globally. Moreover, central banks have been forced to decrease the interest rates to below zero for most countries. It could be tested whether the efficient market hypothesis holds in a dynamic environment of news shocks appearing every day. For the analysis about Finland, the research would benefit from including more companies as a proxy for stock prices. As for the UK, it could be beneficial to use an event-study approach which concentrates on particular dates for monetary policy shock. For example, the dates of MPC decision making could be used. This approach would yield much more precise results. The event-study through heteroscedasticity approach recommended by Rigobon and Sack (2004) could be useful as it utilizes the monetary policy heteroscedasticity for the identification. This thesis has not dwelled deep into the analysis of macroeconomic variables as the identification scheme does not allow for monetary policy to have an effect on them. However, the study of those effects could be very beneficial for policy implications as it could show clearly through which channel the monetary policy is affecting the stock prices. Because such analysis requires for intensive methods, data and research to avoid endogeneity, it is left out of this thesis. There are not many papers that looks at Finnish stock market and their movements, hence, there is a lot of scope for the future research. Moreover, as suggested by Li et al. (2010), future research would also benefit from incorporating wealth effects into the model as that would show the transmission of monetary policy in an open economy. This could be done by including a real estate variable in the model, for example.

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APPENDIX A.

Cargotec Oyj (B-osake)	Nokian Renkaat Oyj
Elisa Oyj	Nordea Bank Oyj
Fortum Oyj	Orion Oyj (B-osake)
Huhtamäki Oyj	Outokumpu Oyj
Kemira Oyj	Outotec Oyj
Kesko Oyj (B-osake)	Sampo Oyj (A-osake)
Kojamo	Stora Enso Oyj (R-osake)
Konecranes Oyj	Telia Company AB
KONE Oyj	Tieto Oyj
Metso Oyj	UPM-Kymmene Oyj
Metsä Board Oyj (B-osake)	Valmet Oyj
Neste Oyj	Wärtsilä Oyj Abp
Nokia Oyj	

Table A. 1: Full List of Companies OMXH25

Associated British Foods	EasyJet	Intertek	Ocado	Rentokil Initial	Tesco
Admiral	Ferguson	ITV	Phoenix Group	Sainsbury (J)	Taylor Wimpey
Ashtead	Flutter Entertainment	JD Sports Fashion	Pennon	Schroders Vtg	Unilever
Antofagasta	Fresnillo	Just Eat Takeaway.com	Polymetal International	Sage	United Utilities
Auto Trader	Glencore	Johnson Matthey	Prudential	Segro	Vodafone
Aviva	GlaxoSmithKline	Land Securities	Persimmon	Smurfit Kappa	Whitbread
Aveva	Hikma Pharmaceuticals	Legal & General	Pearson	Standard Life Aberdeen	Wm Morrison Supermarkets
Astrazeneca	Hargreaves Lansdown	Lloyds Banking	Reckitt Benckiser	Smith (DS)	WPP
BAE Systems	Halma	London Stock Exchange	Royal Bank of Scotland	Smiths Group	Wm Morrison Supermarkets plc
Barclays	HSBC	Meggitt	Royal Dutch Shell A	Scottish Mortgage Inv Tst	WPP PLC
BAT	Intl Consolidated Airlines	Mondi	Royal Dutch Shell B	Smith & Nephew	Anglo American
Barratt Developments	Intermediate Capital	M&G	Relx	Spirax-Sarco Engineering	Burberry
BHP Group	Intercontinental Hotels	Melrose Industries	Rio Tinto	SSE	BT
Berkeley	3i	Morrison (Wm)	Rightmove	Standard Chartered	Carnival plc (UK)
British Land	Imperial Brands	National Grid	Rolls-Royce	St James's Place	Centrica
Bunzl	Informa	Next	RSA Insurance	Severn Trent	Diageo
BP	Compass	Croda International	CRH	DCC	

Table A. 2: Full list of companies FTSE100

APPENDIX A.1: Results for Finland

Null Hypothesis: LOGSP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.190147	0.2106
Test critical values:	1% level	-3.464827	
	5% level	-2.876595	
	10% level	-2.574874	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGSP)
Method: Least Squares
Date: 06/12/20 Time: 18:56
Sample (adjusted): 2003M03 2018M12
Included observations: 190 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGSP(-1)	-0.032623	0.014895	-2.190147	0.0298
D(LOGSP(-1))	0.142596	0.071659	1.989918	0.0481
C	0.252078	0.113187	2.227085	0.0271

R-squared	0.041594	Mean dependent var	0.004983
Adjusted R-squared	0.031343	S.D. dependent var	0.058739
S.E. of regression	0.057811	Akaike info criterion	-2.847619
Sum squared resid	0.624970	Schwarz criterion	-2.796350
Log likelihood	273.5238	Hannan-Quinn criter.	-2.826851
F-statistic	4.057798	Durbin-Watson stat	2.028190
Prob(F-statistic)	0.018832		

Table A.1. 1: ADF Results for Stock Price Index

Null Hypothesis: D(LOGSP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.05618	0.0000
Test critical values:	1% level	-3.464827	
	5% level	-2.876595	
	10% level	-2.574874	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGSP,2)
Method: Least Squares
Date: 06/12/20 Time: 18:57
Sample (adjusted): 2003M03 2018M12
Included observations: 190 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGSP(-1))	-0.869865	0.072151	-12.05618	0.0000
C	0.004352	0.004251	1.023919	0.3072

R-squared	0.436031	Mean dependent var	0.000134
Adjusted R-squared	0.433031	S.D. dependent var	0.077548
S.E. of regression	0.058392	Akaike info criterion	-2.832818
Sum squared resid	0.641001	Schwarz criterion	-2.798639
Log likelihood	271.1177	Hannan-Quinn criter.	-2.818972
F-statistic	145.3515	Durbin-Watson stat	2.016000
Prob(F-statistic)	0.000000		

Table A.1. 2: ADF Results for Stock Price Index (First Difference)

Null Hypothesis: REFINANCING_RATE has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.482329	0.5405
Test critical values:	1% level	-3.465977	
	5% level	-2.877099	
	10% level	-2.575143	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(REFINANCING_RATE)
Method: Least Squares
Date: 06/12/20 Time: 18:57
Sample (adjusted): 2003M09 2018M12
Included observations: 184 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REFINANCING_RATE(-1)	-0.012065	0.008139	-1.482329	0.1401
D(REFINANCING_RATE(-1))	0.309030	0.073725	4.191690	0.0000
D(REFINANCING_RATE(-2))	0.230115	0.076294	3.016165	0.0029
D(REFINANCING_RATE(-3))	0.230804	0.074285	3.107029	0.0022
D(REFINANCING_RATE(-4))	-0.130149	0.075397	-1.726173	0.0861
D(REFINANCING_RATE(-5))	-0.097863	0.073175	-1.337396	0.1828
D(REFINANCING_RATE(-6))	-0.129640	0.071993	-1.800730	0.0735
D(REFINANCING_RATE(-7))	0.186259	0.070206	2.653034	0.0087
C	0.004911	0.010057	0.488351	0.6259

R-squared	0.291336	Mean dependent var	-0.007609
Adjusted R-squared	0.258940	S.D. dependent var	0.131289
S.E. of regression	0.113020	Akaike info criterion	-1.474825
Sum squared resid	2.235371	Schwarz criterion	-1.317573
Log likelihood	144.6839	Hannan-Quinn criter.	-1.411089
F-statistic	8.992963	Durbin-Watson stat	2.029062
Prob(F-statistic)	0.000000		

Table A.1. 3: ADF Test for Refinancing Rate (Monetary Policy)

Null Hypothesis: D(REFINANCING_RATE) has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.164790	0.0010
Test critical values:	1% level	-3.465977	
	5% level	-2.877099	
	10% level	-2.575143	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(REFINANCING_RATE,2)
Method: Least Squares
Date: 06/12/20 Time: 18:57
Sample (adjusted): 2003M09 2018M12
Included observations: 184 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(REFINANCING_RATE(-1))	-0.446335	0.107169	-4.164790	0.0000
D(REFINANCING_RATE(-1),2)	-0.247230	0.104417	-2.367707	0.0190
D(REFINANCING_RATE(-2),2)	-0.021755	0.098692	-0.220438	0.8258
D(REFINANCING_RATE(-3),2)	0.204964	0.094818	2.161665	0.0320
D(REFINANCING_RATE(-4),2)	0.069331	0.094608	0.732825	0.4646
D(REFINANCING_RATE(-5),2)	-0.036580	0.087035	-0.420291	0.6748
D(REFINANCING_RATE(-6),2)	-0.175236	0.070048	-2.501648	0.0133
C	-0.003287	0.008428	-0.390036	0.6970

R-squared	0.389085	Mean dependent var	0.000000
Adjusted R-squared	0.364788	S.D. dependent var	0.142288
S.E. of regression	0.113404	Akaike info criterion	-1.473217
Sum squared resid	2.263439	Schwarz criterion	-1.333437
Log likelihood	143.5360	Hannan-Quinn criter.	-1.416563
F-statistic	16.01323	Durbin-Watson stat	2.021432
Prob(F-statistic)	0.000000		

Table A.1. 4: ADF Test for Refinancing Rate (Monetary Policy, First Difference)

Null Hypothesis: LOGCP has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.327641	0.6165
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGCP)
Method: Least Squares
Date: 06/12/20 Time: 18:59
Sample (adjusted): 2003M04 2018M12
Included observations: 189 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGCP(-1)	-0.005598	0.004216	-1.327641	0.1859
D(LOGCP(-1))	0.452726	0.073277	6.178281	0.0000
D(LOGCP(-2))	0.099041	0.073104	1.354803	0.1771
C	0.026014	0.019144	1.358866	0.1758

R-squared	0.264823	Mean dependent var	0.001412
Adjusted R-squared	0.252902	S.D. dependent var	0.006388
S.E. of regression	0.005521	Akaike info criterion	-7.539466
Sum squared resid	0.005640	Schwarz criterion	-7.470857
Log likelihood	716.4795	Hannan-Quinn criter.	-7.511671
F-statistic	22.21341	Durbin-Watson stat	1.952805
Prob(F-statistic)	0.000000		

Table A.1. 5: ADF Result for Commodity Prices

Null Hypothesis: D(LOGCP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.874596	0.0000
Test critical values:	1% level	-3.464827	
	5% level	-2.876595	
	10% level	-2.574874	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGCP,2)
Method: Least Squares
Date: 06/12/20 Time: 18:59
Sample (adjusted): 2003M03 2018M12
Included observations: 190 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGCP(-1))	-0.499010	0.063370	-7.874596	0.0000
C	0.000664	0.000412	1.610522	0.1090

R-squared	0.248028	Mean dependent var	-7.97E-05
Adjusted R-squared	0.244028	S.D. dependent var	0.006365
S.E. of regression	0.005534	Akaike info criterion	-7.545395
Sum squared resid	0.005757	Schwarz criterion	-7.511216
Log likelihood	718.8126	Hannan-Quinn criter.	-7.531550
F-statistic	62.00927	Durbin-Watson stat	2.076023
Prob(F-statistic)	0.000000		

Table A.1. 6: ADF Result for Commodity Prices (First Difference)

Null Hypothesis: LOGINF has a unit root
Exogenous: Constant
Lag Length: 14 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.604218	0.4783
Test critical values:	1% level	-3.467418	
	5% level	-2.877729	
	10% level	-2.575480	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGINF)
Method: Least Squares
Date: 06/12/20 Time: 19:00
Sample (adjusted): 2004M04 2018M12
Included observations: 177 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGINF(-1)	-0.004232	0.002638	-1.604218	0.1106
D(LOGINF(-1))	0.023155	0.075420	0.307011	0.7592
D(LOGINF(-2))	0.255825	0.074954	3.413099	0.0008
D(LOGINF(-3))	0.020570	0.069126	0.297568	0.7664
D(LOGINF(-4))	-0.054672	0.068822	-0.794407	0.4281
D(LOGINF(-5))	-0.037238	0.068638	-0.542527	0.5882
D(LOGINF(-6))	0.193180	0.068149	2.834658	0.0052
D(LOGINF(-7))	0.060675	0.069446	0.873704	0.3836
D(LOGINF(-8))	-0.046880	0.069377	-0.675724	0.5002
D(LOGINF(-9))	-0.117042	0.066797	-1.752199	0.0816
D(LOGINF(-10))	-0.074431	0.067307	-1.105844	0.2704
D(LOGINF(-11))	0.084739	0.067493	1.255520	0.2111
D(LOGINF(-12))	0.440229	0.068016	6.472385	0.0000
D(LOGINF(-13))	-0.090999	0.073375	-1.240189	0.2167
D(LOGINF(-14))	-0.204619	0.073535	-2.782604	0.0060
C	0.020916	0.012629	1.656129	0.0996

R-squared	0.381692	Mean dependent var	0.001225
Adjusted R-squared	0.324086	S.D. dependent var	0.002990
S.E. of regression	0.002458	Akaike info criterion	-9.092524
Sum squared resid	0.000973	Schwarz criterion	-8.805414
Log likelihood	820.6883	Hannan-Quinn criter.	-8.976083
F-statistic	6.625870	Durbin-Watson stat	2.068534
Prob(F-statistic)	0.000000		

Table A.1. 7: ADF Test Results for Inflation (CPI)

Null Hypothesis: D(LOGINF) has a unit root
Exogenous: Constant
Lag Length: 14 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.276094	0.0175
Test critical values:	1% level	-3.467633	
	5% level	-2.877823	
	10% level	-2.575530	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGINF,2)
Method: Least Squares
Date: 06/12/20 Time: 19:00
Sample (adjusted): 2004M05 2018M12
Included observations: 176 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGINF(-1))	-0.595333	0.181720	-3.276094	0.0013
D(LOGINF(-1),2)	-0.406041	0.180848	-2.245213	0.0261
D(LOGINF(-2),2)	-0.158939	0.182982	-0.868606	0.3864
D(LOGINF(-3),2)	-0.070217	0.183026	-0.383645	0.7018
D(LOGINF(-4),2)	-0.108717	0.177105	-0.613858	0.5402
D(LOGINF(-5),2)	-0.153731	0.169223	-0.908453	0.3650
D(LOGINF(-6),2)	0.027939	0.163293	0.171096	0.8644
D(LOGINF(-7),2)	0.087979	0.158356	0.555577	0.5793
D(LOGINF(-8),2)	0.051119	0.153516	0.332987	0.7396
D(LOGINF(-9),2)	-0.039275	0.147369	-0.266510	0.7902
D(LOGINF(-10),2)	-0.118869	0.135906	-0.874641	0.3831
D(LOGINF(-11),2)	-0.040467	0.125410	-0.322675	0.7474
D(LOGINF(-12),2)	0.402250	0.114884	3.501341	0.0006
D(LOGINF(-13),2)	0.341528	0.104063	3.281938	0.0013
D(LOGINF(-14),2)	0.138138	0.075550	1.828449	0.0693
C	0.000745	0.000285	2.618495	0.0097

R-squared	0.663603	Mean dependent var	-7.18E-06
Adjusted R-squared	0.632066	S.D. dependent var	0.004056
S.E. of regression	0.002460	Akaike info criterion	-9.090688
Sum squared resid	0.000968	Schwarz criterion	-8.802462
Log likelihood	815.9805	Hannan-Quinn criter.	-8.973785
F-statistic	21.04190	Durbin-Watson stat	1.996834
Prob(F-statistic)	0.000000		

Table A.1. 8: ADF Test Results for Inflation (CPI, First Difference)

Null Hypothesis: LOGIP has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.955817	0.3063
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGIP)
Method: Least Squares
Date: 06/12/20 Time: 19:01
Sample (adjusted): 2003M04 2018M12
Included observations: 189 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGIP(-1)	-0.055927	0.028595	-1.955817	0.0520
D(LOGIP(-1))	-0.251406	0.073477	-3.421536	0.0008
D(LOGIP(-2))	-0.153542	0.072178	-2.127288	0.0347
C	0.262538	0.133772	1.962573	0.0512

R-squared	0.106091	Mean dependent var	0.000703
Adjusted R-squared	0.091596	S.D. dependent var	0.026572
S.E. of regression	0.025326	Akaike info criterion	-4.493032
Sum squared resid	0.118660	Schwarz criterion	-4.424424
Log likelihood	428.5915	Hannan-Quinn criter.	-4.465237
F-statistic	7.318764	Durbin-Watson stat	1.964622
Prob(F-statistic)	0.000116		

Table A.1. 9: ADF Test Results for Industrial Production

Null Hypothesis: D(LOGIP) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.84295	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGIP,2)
Method: Least Squares
Date: 06/12/20 Time: 19:01
Sample (adjusted): 2003M04 2018M12
Included observations: 189 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGIP(-1))	-1.459486	0.113641	-12.84295	0.0000
D(LOGIP(-1),2)	0.175019	0.071877	2.434970	0.0158
C	0.000929	0.001857	0.500028	0.6176

R-squared	0.633829	Mean dependent var	0.000263
Adjusted R-squared	0.629891	S.D. dependent var	0.041945
S.E. of regression	0.025518	Akaike info criterion	-4.483148
Sum squared resid	0.121114	Schwarz criterion	-4.431692
Log likelihood	426.6575	Hannan-Quinn criter.	-4.462302
F-statistic	160.9795	Durbin-Watson stat	1.968386
Prob(F-statistic)	0.000000		

Table A.1. 10. ADF Test Results for Industrial Production (First Difference)

VAR Lag Order Selection Criteria
Endogenous variables: DLOGIP DLOGINF DLOGCP DLOGSP DMP
Exogenous variables: C FINANCIAL_CRISIS
Date: 06/13/20 Time: 15:49
Sample: 2003M01 2018M12
Included observations: 183

Lag	LogL	LR	FPE	AIC	SC	HQ
0	2307.284	NA	8.59e-18	-25.10693	-24.93155	-25.03584
1	2372.431	125.3104	5.54e-18	-25.54570	-24.93186*	-25.29688*
2	2403.099	57.31391	5.21e-18	-25.60764	-24.55535	-25.18110
3	2431.785	52.04252	5.01e-18*	-25.64793*	-24.15718	-25.04365
4	2451.698	35.03825	5.32e-18	-25.59233	-23.66313	-24.81033
5	2468.707	28.99793	5.83e-18	-25.50499	-23.13734	-24.54527
6	2498.266	48.78091*	5.59e-18	-25.55482	-22.74871	-24.41737
7	2520.175	34.95903	5.84e-18	-25.52104	-22.27648	-24.20586
8	2543.196	35.47378	6.05e-18	-25.49940	-21.81639	-24.00650

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table A.1. 11: Lag-Length Selection

VAR Residual Serial Correlation LM Tests
Date: 06/12/20 Time: 19:03
Sample: 2003M01 2018M12
Included observations: 188

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	35.27125	25	0.0834	1.424944	(25, 603.3)	0.0835
2	48.39844	25	0.0033	1.976502	(25, 603.3)	0.0033
3	28.85908	25	0.2698	1.159778	(25, 603.3)	0.2700
4	22.14863	25	0.6271	0.885223	(25, 603.3)	0.6273

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	35.27125	25	0.0834	1.424944	(25, 603.3)	0.0835
2	71.58169	50	0.0243	1.454309	(50, 719.4)	0.0244
3	101.5180	75	0.0225	1.378311	(75, 732.3)	0.0228
4	135.4536	100	0.0106	1.386704	(100, 721.8)	0.0109

*Edgeworth expansion corrected likelihood ratio statistic.

Table A.1. 12: Autocorrelation Test Results

Roots of Characteristic Polynomial
Endogenous variables: DLOGIP DLOGINF DLOGCP DLOGSP DMP
Exogenous variables: C FINANCIAL_CRISIS
Lag specification: 1 3
Date: 06/13/20 Time: 16:24

Root	Modulus
0.685437 - 0.232068i	0.723657
0.685437 + 0.232068i	0.723657
0.623465	0.623465
-0.253084 - 0.554519i	0.609543
-0.253084 + 0.554519i	0.609543
0.001414 - 0.604591i	0.604593
0.001414 + 0.604591i	0.604593
-0.510439 - 0.318522i	0.601669
-0.510439 + 0.318522i	0.601669
-0.597387	0.597387
0.249661 - 0.490524i	0.550403
0.249661 + 0.490524i	0.550403
-0.113494 - 0.389866i	0.406050
-0.113494 + 0.389866i	0.406050
-0.200152	0.200152

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table A.1. 13: Stability of VAR

Structural VAR Estimates
Date: 06/13/20 Time: 15:42
Sample (adjusted): 2003M05 2018M12
Included observations: 188 after adjustments
Estimation method: Maximum likelihood via Newton-Raphson (analytic derivatives)
Convergence achieved after 25 iterations
Structural VAR is just-identified

Model: e = Su where E[uu']=I
S =

C(1)	0	0	0	0
C(2)	C(6)	0	0	0
C(3)	C(7)	C(10)	0	0
C(4)	C(8)	C(11)	C(13)	C(15)
C(5)	C(9)	C(12)	C(14)	-81.3 * C(15)

including the restriction(s)
F =

NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
NA	NA	NA	NA	0
NA	NA	NA	NA	NA

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.023438	0.001209	19.39072	0.0000
C(2)	8.44E-05	0.000207	0.408197	0.6831
C(3)	0.001037	0.000382	2.710789	0.0067
C(4)	-0.004204	0.004157	-1.011344	0.3119
C(5)	0.020884	0.007597	2.748917	0.0060
C(6)	0.002834	0.000146	19.39072	0.0000
C(7)	0.001888	0.000366	5.158705	0.0000
C(8)	-0.002808	0.004148	-0.676762	0.4986
C(9)	0.007944	0.007509	1.057810	0.2901
C(10)	0.004838	0.000249	19.39072	0.0000
C(11)	0.012303	0.004097	3.002932	0.0027
C(12)	0.013625	0.007465	1.825149	0.0680
C(13)	0.055484	0.002863	19.38090	0.0000
C(14)	0.007461	0.007422	1.005191	0.3148
C(15)	-0.001249	6.44E-05	-19.39072	0.0000
Log likelihood	2450.132			

Estimated S matrix:

0.023438	0.000000	0.000000	0.000000	0.000000
8.44E-05	0.002834	0.000000	0.000000	0.000000
0.001037	0.001888	0.004838	0.000000	0.000000
-0.004204	-0.002808	0.012303	0.055484	-0.001249
0.020884	0.007944	0.013625	0.007461	0.101631

Estimated F matrix:

0.016947	-0.002772	0.006790	0.010294	0.003857
0.000409	0.002773	0.001519	0.000628	-3.25E-05
0.002929	0.002866	0.009337	0.004936	-0.000485
0.010788	-0.020388	-0.007598	0.060793	0.000000
0.081492	-0.005209	0.121119	0.153192	0.132517

Table A.1. 14: SVAR Result

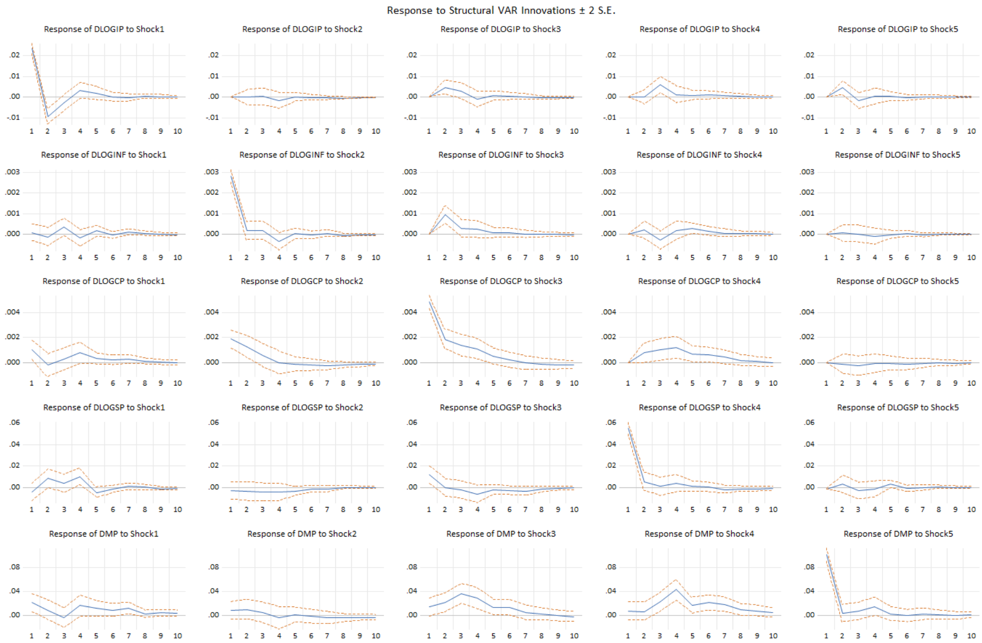

Table A.1. 15: Impulse Response Functions (All Variables)

APPENDIX A.2: Results for the UK

Null Hypothesis: LOGSP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.232901	0.6600
Test critical values:	1% level	-3.464827	
	5% level	-2.876595	
	10% level	-2.574874	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGSP)
Method: Least Squares
Date: 06/12/20 Time: 12:41
Sample (adjusted): 2003M03 2018M12
Included observations: 190 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGSP(-1)	-0.013048	0.010583	-1.232901	0.2192
D(LOGSP(-1))	0.237721	0.070957	3.350187	0.0010
C	0.275447	0.214994	1.281183	0.2017

R-squared	0.060964	Mean dependent var	0.013613
Adjusted R-squared	0.050921	S.D. dependent var	0.170707
S.E. of regression	0.166304	Akaike info criterion	-0.734337
Sum squared resid	5.171854	Schwarz criterion	-0.683068
Log likelihood	72.76200	Hannan-Quinn criter.	-0.713569
F-statistic	6.070205	Durbin-Watson stat	2.008879
Prob(F-statistic)	0.002791		

Table A.2. 1: ADF Test Results for the Stock Price Index

Null Hypothesis: D(LOGSP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.86809	0.0000
Test critical values:	1% level	-3.464827	
	5% level	-2.876595	
	10% level	-2.574874	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGSP,2)
Method: Least Squares
Date: 06/12/20 Time: 12:41
Sample (adjusted): 2003M03 2018M12
Included observations: 190 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGSP(-1))	-0.769559	0.070809	-10.86809	0.0000
C	0.010800	0.012112	0.891657	0.3737

R-squared	0.385852	Mean dependent var	0.001408
Adjusted R-squared	0.382586	S.D. dependent var	0.211940
S.E. of regression	0.166534	Akaike info criterion	-0.736767
Sum squared resid	5.213893	Schwarz criterion	-0.702588
Log likelihood	71.99291	Hannan-Quinn criter.	-0.722922
F-statistic	118.1154	Durbin-Watson stat	2.004097
Prob(F-statistic)	0.000000		

Table A.2. 2: ADF Test Results for the Stock Price Index (First Difference)

Null Hypothesis: BANK_RATE has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.171329	0.6866
Test critical values:	1% level	-3.465585	
	5% level	-2.876927	
	10% level	-2.575051	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BANK_RATE)
Method: Least Squares
Date: 06/12/20 Time: 12:43
Sample (adjusted): 2003M07 2018M12
Included observations: 186 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BANK_RATE(-1)	-0.005770	0.004926	-1.171329	0.2430
D(BANK_RATE(-1))	0.529633	0.073555	7.200467	0.0000
D(BANK_RATE(-2))	0.147712	0.083087	1.777793	0.0771
D(BANK_RATE(-3))	-0.038853	0.083761	-0.463863	0.6433
D(BANK_RATE(-4))	0.121569	0.083274	1.459863	0.1461
D(BANK_RATE(-5))	-0.151925	0.074621	-2.035947	0.0432
C	0.005038	0.014132	0.356485	0.7219

R-squared	0.395839	Mean dependent var	-0.016129
Adjusted R-squared	0.375588	S.D. dependent var	0.169684
S.E. of regression	0.134084	Akaike info criterion	-1.143800
Sum squared resid	3.218131	Schwarz criterion	-1.022401
Log likelihood	113.3734	Hannan-Quinn criter.	-1.094604
F-statistic	19.54645	Durbin-Watson stat	1.954677
Prob(F-statistic)	0.000000		

Table A.2. 3: ADF Results for the bank rate (Monetary Policy)

Null Hypothesis: D(BANK_RATE) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.425368	0.0004
Test critical values:	1% level	-3.465780	
	5% level	-2.877012	
	10% level	-2.575097	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BANK_RATE,2)
Method: Least Squares
Date: 06/12/20 Time: 12:43
Sample (adjusted): 2003M08 2018M12
Included observations: 185 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BANK_RATE(-1))	-0.372080	0.084079	-4.425368	0.0000
D(BANK_RATE(-1),2)	-0.082356	0.090067	-0.914388	0.3618
D(BANK_RATE(-2),2)	0.054292	0.088330	0.614649	0.5396
D(BANK_RATE(-3),2)	0.016334	0.084385	0.193567	0.8467
D(BANK_RATE(-4),2)	0.123798	0.081412	1.520643	0.1301
D(BANK_RATE(-5),2)	-0.079365	0.074961	-1.058750	0.2911
C	-0.004850	0.009903	-0.489731	0.6249

R-squared	0.244505	Mean dependent var	0.001351
Adjusted R-squared	0.219038	S.D. dependent var	0.150852
S.E. of regression	0.133311	Akaike info criterion	-1.155161
Sum squared resid	3.163382	Schwarz criterion	-1.033310
Log likelihood	113.8524	Hannan-Quinn criter.	-1.105778
F-statistic	9.601162	Durbin-Watson stat	1.978447
Prob(F-statistic)	0.000000		

Table A.2. 4: ADF Results for the bank rate (Monetary Policy, First Difference)

Null Hypothesis: LOGIP has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.282601	0.0171
Test critical values:	1% level	-3.466176	
	5% level	-2.877186	
	10% level	-2.575189	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGIP)
Method: Least Squares
Date: 06/12/20 Time: 12:59
Sample (adjusted): 2003M10 2018M12
Included observations: 183 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGIP(-1)	-0.076945	0.023440	-3.282601	0.0012
D(LOGIP(-1))	-0.153003	0.072807	-2.101500	0.0370
D(LOGIP(-2))	0.019528	0.073298	0.266414	0.7902
D(LOGIP(-3))	0.111046	0.073202	1.516986	0.1311
D(LOGIP(-4))	0.096234	0.073539	1.308613	0.1924
D(LOGIP(-5))	0.041625	0.073898	0.563278	0.5740
D(LOGIP(-6))	0.114374	0.073946	1.546721	0.1238
D(LOGIP(-7))	0.183515	0.074383	2.467173	0.0146
D(LOGIP(-8))	0.257535	0.073513	3.503253	0.0006
C	0.354574	0.108006	3.282901	0.0012

R-squared	0.143222	Mean dependent var	0.000135
Adjusted R-squared	0.098650	S.D. dependent var	0.009487
S.E. of regression	0.009007	Akaike info criterion	-6.528590
Sum squared resid	0.014034	Schwarz criterion	-6.353208
Log likelihood	607.3660	Hannan-Quinn criter.	-6.457499
F-statistic	3.213250	Durbin-Watson stat	2.027629
Prob(F-statistic)	0.001260		

Table A.2. 5: ADF Test Results for Industrial Production

Null Hypothesis: LOGINF has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.078899	0.2535
Test critical values:	1% level	-3.464827	
	5% level	-2.876595	
	10% level	-2.574874	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGINF)
Method: Least Squares
Date: 06/12/20 Time: 13:01
Sample (adjusted): 2003M03 2018M12
Included observations: 190 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGINF(-1)	-0.036332	0.017477	-2.078899	0.0390
D(LOGINF(-1))	0.211816	0.071372	2.967773	0.0034
C	0.181207	0.087421	2.072797	0.0396

R-squared	0.059415	Mean dependent var	0.001174
Adjusted R-squared	0.049355	S.D. dependent var	0.144488
S.E. of regression	0.140877	Akaike info criterion	-1.066197
Sum squared resid	3.711259	Schwarz criterion	-1.014928
Log likelihood	104.2887	Hannan-Quinn criter.	-1.045429
F-statistic	5.906202	Durbin-Watson stat	1.977191
Prob(F-statistic)	0.003256		

Table A.2. 6: ADF Results for Inflation (CPI)

Null Hypothesis: D(LOGINF) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.27816	0.0000
Test critical values:	1% level	-3.464827	
	5% level	-2.876595	
	10% level	-2.574874	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGINF,2)
Method: Least Squares
Date: 06/12/20 Time: 13:01
Sample (adjusted): 2003M03 2018M12
Included observations: 190 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGINF(-1))	-0.806090	0.071474	-11.27816	0.0000
C	0.000713	0.010312	0.069160	0.9449

R-squared	0.403547	Mean dependent var	-0.001204
Adjusted R-squared	0.400375	S.D. dependent var	0.183528
S.E. of regression	0.142116	Akaike info criterion	-1.053875
Sum squared resid	3.797032	Schwarz criterion	-1.019696
Log likelihood	102.1181	Hannan-Quinn criter.	-1.040029
F-statistic	127.1969	Durbin-Watson stat	1.970727
Prob(F-statistic)	0.000000		

Table A.2. 7: ADF Results for Inflation (CPI, First Difference)

Null Hypothesis: LOGCP has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.201385	0.6738
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGCP)
Method: Least Squares
Date: 06/12/20 Time: 13:02
Sample (adjusted): 2003M04 2018M12
Included observations: 189 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGCP(-1)	-0.003848	0.003203	-1.201385	0.2311
D(LOGCP(-1))	0.665565	0.073063	9.109486	0.0000
D(LOGCP(-2))	-0.121682	0.073152	-1.663408	0.0979
C	0.018321	0.014570	1.257436	0.2102

R-squared	0.366211	Mean dependent var	0.001924
Adjusted R-squared	0.355933	S.D. dependent var	0.006370
S.E. of regression	0.005112	Akaike info criterion	-7.693381
Sum squared resid	0.004835	Schwarz criterion	-7.624773
Log likelihood	731.0245	Hannan-Quinn criter.	-7.665586
F-statistic	35.63172	Durbin-Watson stat	1.928844
Prob(F-statistic)	0.000000		

Table A.2. 8: ADF Test Results for Commodity Prices

Null Hypothesis: D(LOGCP) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.863039	0.0000
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGCP,2)
Method: Least Squares
Date: 06/12/20 Time: 13:02
Sample (adjusted): 2003M04 2018M12
Included observations: 189 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGCP(-1))	-0.454243	0.066187	-6.863039	0.0000
D(LOGCP(-1),2)	0.123741	0.073219	1.690002	0.0927
C	0.000823	0.000396	2.076569	0.0392

R-squared	0.210747	Mean dependent var	-0.000105
Adjusted R-squared	0.202260	S.D. dependent var	0.005731
S.E. of regression	0.005118	Akaike info criterion	-7.696192
Sum squared resid	0.004873	Schwarz criterion	-7.644735
Log likelihood	730.2901	Hannan-Quinn criter.	-7.675346
F-statistic	24.83286	Durbin-Watson stat	1.929090
Prob(F-statistic)	0.000000		

Table A.2. 9: ADF Test Results for Commodity Prices (First Difference)

VAR Lag Order Selection Criteria
Endogenous variables: DMP DLOGSP DLOGCP DLOGINF LOGIP
Exogenous variables: C FINANCIAL_CRISIS
Date: 06/12/20 Time: 14:03
Sample: 2003M01 2018M12
Included observations: 183

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1418.222	NA	1.42e-13	-15.39041	-15.21503	-15.31932
1	1734.789	608.9156	5.89e-15*	-18.57693*	-17.96309*	-18.32811*
2	1757.002	41.51325	6.07e-15	-18.54647	-17.49418	-18.11993
3	1783.918	48.83128	5.96e-15	-18.56741	-17.07667	-17.96314
4	1797.593	24.06195	6.76e-15	-18.44364	-16.51444	-17.66164
5	1820.130	38.42341	6.98e-15	-18.41672	-16.04907	-17.45700
6	1841.931	35.97766	7.28e-15	-18.38176	-15.57565	-17.24431
7	1869.628	44.19439*	7.14e-15	-18.41124	-15.16668	-17.09606
8	1883.708	21.69713	8.16e-15	-18.29190	-14.60888	-16.79899

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion

Table A.2. 10: Lag-Length Selection

VAR Residual Serial Correlation LM Tests
Date: 06/12/20 Time: 14:02
Sample: 2003M01 2018M12
Included observations: 187

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	33.61449	25	0.1164	1.356601	(25, 581.0)	0.1165
2	18.34850	25	0.8272	0.730954	(25, 581.0)	0.8273
3	19.48088	25	0.7735	0.776811	(25, 581.0)	0.7736
4	26.17407	25	0.3984	1.049656	(25, 581.0)	0.3986
5	37.26948	25	0.0544	1.508799	(25, 581.0)	0.0545

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	33.61449	25	0.1164	1.356601	(25, 581.0)	0.1165
2	64.12575	50	0.0864	1.296727	(50, 692.0)	0.0868
3	94.12578	75	0.0669	1.272309	(75, 703.5)	0.0677
4	117.1118	100	0.1163	1.184831	(100, 692.5)	0.1187
5	157.6575	125	0.0256	1.289012	(125, 674.2)	0.0270

*Edgeworth expansion corrected likelihood ratio statistic.

Table A.2. 11: Autocorrelation Test

Roots of Characteristic Polynomial
Endogenous variables: LOGIP DLOGINF DLOGCP DLOGSP DMP
Exogenous variables: C FINANCIAL_CRISIS
Lag specification: 1 1
Date: 06/13/20 Time: 16:45

Root	Modulus
0.948640	0.948640
0.567621	0.567621
0.193438	0.193438
-0.146345	0.146345
0.051398	0.051398

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table A.2. 12: Stability Condition

Structural VAR Estimates
Date: 06/13/20 Time: 16:42
Sample (adjusted): 2003M03 2018M12
Included observations: 190 after adjustments
Estimation method: Maximum likelihood via Newton-Raphson (analytic derivatives)
Convergence achieved after 18 iterations
Structural VAR is just-identified

Model: e = Su where E[uu']=I

S =

C(1)	0	0	0	0
C(2)	C(6)	0	0	0
C(3)	C(7)	C(10)	0	0
C(4)	C(8)	C(11)	C(13)	C(15)
C(5)	C(9)	C(12)	C(14)	-9.06 * C(15)

including the restriction(s)

F =

NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
NA	NA	NA	NA	0
NA	NA	NA	NA	NA

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.008980	0.000461	19.49359	0.0000
C(2)	-0.018138	0.010104	-1.795114	0.0726
C(3)	0.000135	0.000375	0.358843	0.7197
C(4)	0.025507	0.011681	2.183613	0.0290
C(5)	-0.009322	0.018339	-0.508328	0.6112
C(6)	0.138680	0.007114	19.49359	0.0000
C(7)	0.000884	0.000372	2.372850	0.0177
C(8)	-0.133581	0.009369	-14.25805	0.0000
C(9)	0.020612	0.018303	1.126159	0.2601
C(10)	0.005096	0.000261	19.49359	0.0000
C(11)	0.008314	0.006375	1.304206	0.1922
C(12)	0.056691	0.018039	3.142654	0.0017
C(13)	0.083535	0.004700	17.77324	0.0000
C(14)	0.045897	0.017647	2.600853	0.0093
C(15)	-0.026611	0.001365	-19.49359	0.0000

Log likelihood	1656.678			

Estimated S matrix:

0.008980	0.000000	0.000000	0.000000	0.000000
-0.018138	0.138680	0.000000	0.000000	0.000000
0.000135	0.000884	0.005096	0.000000	0.000000
0.025507	-0.133581	0.008314	0.083535	-0.026611
-0.009322	0.020612	0.056691	0.045897	0.241069

Estimated F matrix:

0.175495	0.017236	0.063753	0.028179	-0.006220
0.039637	0.175595	0.093377	-0.002131	-0.013602
0.004977	0.002303	0.013870	0.000772	-0.001104
-0.064653	-0.185727	-0.113433	0.090494	0.000000
-0.035554	0.038468	0.143263	0.047116	0.202845

Table A.2. 13: SVAR Estimation Result

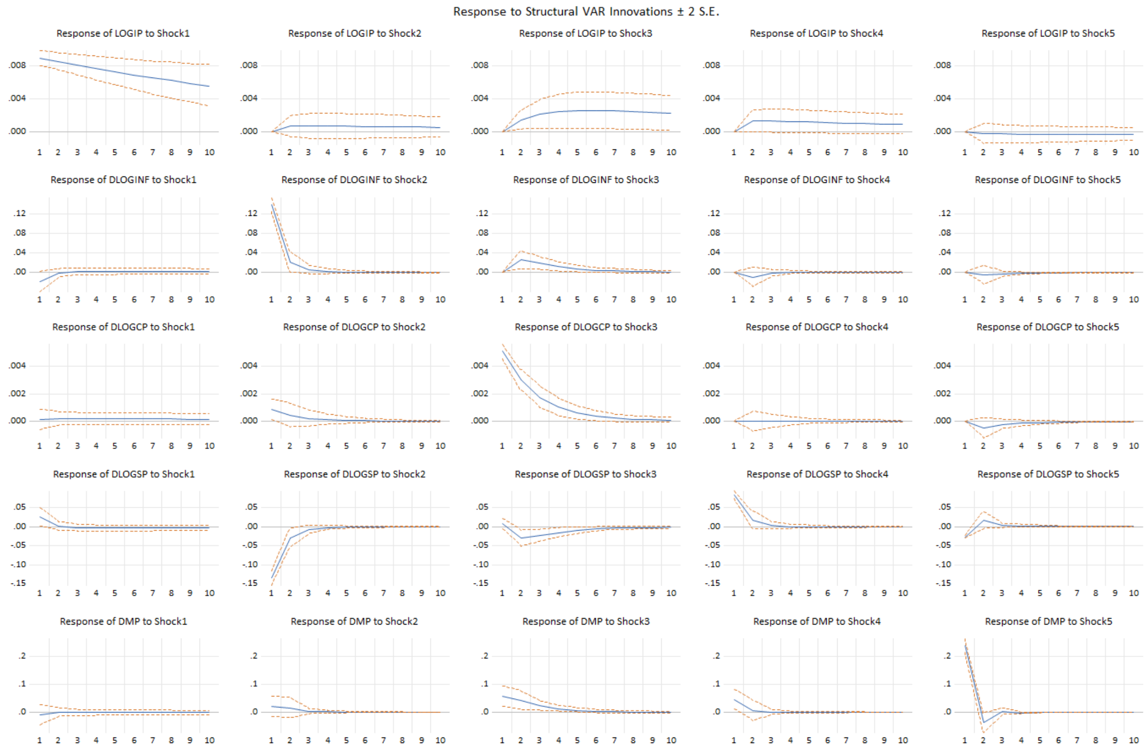

Table A.2. 14: Impulse Responses of All the Variables